INVESTIGATIONS

INTO THE

NATURAL HISTORY OF THE HERRING

IN THE

ATLANTIC WATERS OF CANADA

1914

PRELIMINARY REPORT No. 1.

BY

JOHAN HJORT.

DEPARTMENT OF THE NAVAL SERVICE

SUPPLEMENT

TO THE FIFTH ANNUAL REPORT OF THE DEPARTMENT OF THE NAVAL SERVICE FOR THE FISCAL YEAR ENDING MARCH 31, 1915.

OTTAWA
PRINTED BY J. DE L. TACHÉ, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1915

[No. 38b—1916.]

INVESTIGATIONS INTO THE NATURAL HISTORY OF THE HERRING OF THE ATLANTIC WATERS OF CANADA, 1914.

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When the Biological Board of Canada did me the great honour of asking me to visit Canada for the period of a few months to study the Atlantic herring fisheries, I accepted this invitation with the greatest pleasure, hoping that some useful scientific information might be obtained through a comparison of the herring fisheries of the two sides of the Atlantic, if studied by the methods employed during recent years in north European waters.[1] It was from the beginning understood that a few months' work could aim at nothing more than a preliminary orientation in some of the most fundamental problems. These most important problems seem to me to be the following:—

1. Do the herring that visit the Atlantic coast of Canada all belong to a single race or type, or is it possible to distinguish several races in these waters?

2. Does the rate of growth vary (according to the conditions of the waters along the coast)? Can types of different growth be distinguished and defined?

3. Is the renewal of the stock of herring of a constant character, or are there the same great fluctuations in the stock (in the number of individuals belonging to the different year-classes) as in European waters?

The first two problems or groups of problems are of course identical with the problems of the distribution or migrations of the herring. If the Atlantic stock of herring can be shown to belong to several different races, then of course the area of distribution and migration of each race or type may be defined by a study of samples of herring taken from different localities along the whole coast.

The third problem is of the greatest importance for any elucidation of the old riddle—the fluctuations in the yield of the fisheries—this being to a very great extent dependent on the fluctuations in the number of herring at the time living in the sea.

In order to be able to study these questions, I asked the Biological Board to assist me in getting collections, samples of the catches of the fishermen from different parts of the coast. I have further, for the same purpose, made a journey along that part of the Atlantic coast of North America where herring are caught, from Boston along the Atlantic Coast of Canada to Newfoundland, trying everywhere to get samples for an examination by the methods referred to above. Samples have been collected as follows:—

1. Spring Herring, 1914—

(*a*) Collections from the coasts (west, north, and east) of Newfoundland.

(*b*) Collections from the gulf of St. Lawrence (Magdalen islands, several places in the Northumberland strait, and the west coast of Cape Breton).

[1] See my paper: Fluctuations in the Great Fisheries of Northern Europe. Rapports et Procès-verbaux, Copenhagen, 1914.

2. Fall Herring 1914—

(*a*) West coast of Newfoundland.

(*b*) Atlantic coast of Nova Scotia.

(*c*) Bay of Fundy.

(*d*) Gloucester, Mass.

During my journey along the Atlantic coast I had many opportunities of conversations with business people and fishermen interested in the herring fisheries, and at some places I had the opportunity of seeing the fishing gear and how it was used. The fishermen use, almost without an exception, gill-nets with a certain fixed size of mesh ($2\frac{1}{2}$ to $2\frac{3}{4}$ inches). The nets are placed along the sea-bottom on the coast or in the bays or inlets along the shore. At no point is fishing carried on far out from the coast in deep water, or on the surface(by drift-nets or by purse-seines).

This particular method of fishing has, of course, great disadvantages for the study of the life-history of the herring. The big meshes of the fishermen's nets can procure samples of the large, mature herring only, and it is further quite uncertain whether the samples are in any way representative of even the mature shoals or not. It may be that the fishermen, through a long experience of fishing in these waters, have been able to adopt a size of mesh which takes practically all the sizes of mature herring visiting the coast, but only by means of experiments carried out with gear taking all the sizes probably occurring, can this question be satisfactorily answered. The study of the composition of the stock of herring with regard to age (year classes) will therefore be of a superficial character so long as systematic fishing experiments have not been made.

The methods adopted in the fishing industry at present are further inadequate, for a study of the life-history of the herring, for the reason that the fishing is carried on only along the coast. According to the experience of the fishermen the herring come into the bays or to the coast at a certain time of the year. In Newfoundland (the west coast) for example, in the spring and in the fall the herring appear. When I visited the bays of the west coast of Newfoundland at the beginning of November the fishermen had just begun to catch the herring in the southern bays, while they were still waiting for them in the northern bays (Bonne bay). In conversation with the fishermen I obtained the information that shoals of herring were often seen off the coasts of Nova Scotia, Cape Breton, and Newfoundland, at certain seasons of the year (e.g., in summer) when no herring struck into the shore. A satisfactory study of the life-history of the herring must therefore be based upon material collected by systematic fishing experiments, carried on along the coast and off the coast in the open sea, with such gear that all sizes of herring can be captured. From a perusal of my paper, mentioned above, especially page 59, fig. 34, it will be seen that investigations of the European herring in the North Sea have had to be carried out in this way. Only through an expedition, equipped with gear for the catching of all sizes of herring, and with a sea-going vessel available, will a satisfactory scientific study of the herring be possible.

From the experience which I have obtained during my recent tour, it seems to me quite evident that a thorough scientific investigation of the life-history of the herring must necessarily be of the greatest immediate practical importance. To prove this, I think it sufficient to draw attention to the following circumstances:—

(1) Only large mature herring are taken in the big mesh of the fishermen's nets, whereas in Norway hundreds of thousands of barrels of younger herring ("fat-herring") have been caught every year for centuries.

(2) No Canadian herring fishing is carried on off the coast in the open sea far from land. In the North Sea millions of barrels are caught far from land every year. The coast fishing is comparatively insignificant. In Norway all fishing was coast

fishing until some successful fishing experiments gave satisfactory evidence that herring could just as well be caught off the coast, and hundreds of thousands of barrels have in consequence been caught every year. These considerations are by no means new in the Canadian fisheries. For many years the Canadian Government made efforts to investigate the problem of catching herring in offshore waters, and by drift nets such as are used in European waters.

A steam drifter "No. 33" was bought and brought over from Scotland in the year 1904, and this steamer has, during the years 1904-7 carried out a great number of experiments under the experienced direction of Mr. J. J. Cowie. (See the annual reports of the Department of Marine and Fisheries for the years 1904-7, and a special report by Mr. Cowie published by the department as Bulletin No. 1.) The experiments were in the first years not very successful, but in the year 1907 most promising catches were made off Prince Edward Island, off the Magdalen islands, and off the Gaspé coast. In all these experiments, catches were made (up to sixty-eight and mainly between twenty and thirty barrels in a night) which may be considered satisfactory, especially if the fact be considered that drift-net fishing everywhere must depend on the detailed and local experience which is necessary for making good hauls, and will require fishing operations for some seasons. Further, one boat working alone has greater difficulties in finding the schools of herring than a fleet of boats, and last but not least, fishing experiments, always shifting ground in order to extend the knowledge of a large geographical area, can never be expected to obtain such considerable catches as boats which stay on the field where fishing has proved to give satisfactory results. Mr. Cowie's experiments would thus, in any case, give ample grounds for the expectation that material, for the study of the natural history of the herring, could be got by means of a scheme of drift-net experiments. Indeed, there seemed to me to be so much hope of obtaining practical results of value to the fisheries, through the understanding of the natural history of the herring, that I ventured to propose to the Biological Board of Canada that the study of the Canadian herring should be taken up by a well-planned expedition. Such an expediiton would investigate the sea off Nova Scotia and in the gulf of St. Lawrence during the period extending from May to September.

My proposal was favourably regarded and accepted by the Biological Board, and later by the Department of Naval Service, which granted the means and assistance necessary for the work. A detailed plan for the work was drawn up by the Dominion Commissioner of Fisheries, Prof. E. E. Prince, and myself, as follows:—

1. That the steam drifter "No. 33" be fitted out with drift-nets for the catch of herring and fish in the gulf of St. Lawrence and off the Atlantic coast of Nova Scotia during the suggested time—May to September.

2. That hydrographical and biological investigations be carried out through the assistance of fishery cruisers.

The steam drifter "No. 33" to be fitted out with her gear, etc., in Halifax during the first part of May, and then proceed directly to the gulf of St. Lawrence, in order to carry on herring fishing operations off the coasts of Gaspé, New Brunswick, Prince Edward Island, the Magdalen Islands, and the west shore of Cape Breton. When the season advances the vessel should follow the schools of herrings out to sea, mainly on the bank between the Gaspé coast and Cape Breton, especially with the object of getting samples of the different schools of herrings there. In the late summer she will further have to make test catches of herrings of the west coast of Newfoundland and the east coast of Cape Breton and Nova Scotia.

The hydrographical and biological investigations will mainly aim at the collection of the following material:—

Hydrography.—The distribution of the different water layers (currents) in the gulf and the outside areas, by collection of water samples for determination of salinities (titrations).

Biology.—(*a*) The distribution of the eggs and larvæ of the most important food-fishes, mainly cod, haddock, pollock, mackerel, and herrings. This material will make it possible to outline the areas where these fish spawn, and may thus be caught during their spawning time.

(*b*) The distribution of the most important animals, which serve as food for these fishes, especially the Schizopoda. These investigations may be especially important after the spawning time is over, and the fishes (herrings), are feeding on or outside the spawning banks.

For the combined studies of all material, it seemed important to arrange three series of cruises:—

1. The first, in May, when herring and other fish are spawning, and when the winter conditions still may be found in the sea.
2. The second, in June, when the larvæ of these fish are to be found in the water. As the eggs of herrings are laid on the bottom, they cannot be fished by tow-nets. But in June, when the larvæ escape from the eggs the time will be especially valuable for the location of the spawning grounds of the herring (by means of catching the young larvæ). It will then be possible to determine the first influence of the summer season in the sea.
3. The third series of cruises, at the end of July or in August, when the distribution of young fish (herring, cod., etc.) can be studied, and when the summer conditions of the sea are fully advanced in the different water-layers.

It seems important that each of these series of cruises should follow approximately the same course, as this will facilitate comparison between successive periods, during the season. It is further important to arrange the courses so that the most important banks (spawning grounds) and layers of water can be included, and come under observation. The ideal arrangement of the cruises would seem to be:—

1. A line of stations from Escumenac point (New Brunswick) over the great bank of the gulf of St. Lawrence to the bank east of Anticosti.
2. A line from there across the northern channel to Matashwan bank.
3. From the Matashwan bank to the Bay of Islands (Newfoundland).
4. From St. George's bay (Newfoundland) across the great channel between Newfoundland and Cape Breton, passing cape St. Lawrence and continuing to Pictou island.
5. From Country Harbour, Nova Scotia, over Sable Island bank to the continental slope.
6. From there over the Banquereau, the bank St. Pierre towards Miquelon and St. Pierre islands.
7. From these islands over the Green bank to the Great bank.
8. From Great bank to the southeastern corner of Newfoundland.

Along each of these lines, stations should be determined with a distance of about 20 miles between each station. The average time for the work on a station may approximately be established at from one to one and a half hours. An investigation along these lines would give three cross-sections of the outflowing waters of the St. Lawrence, and of the Atlantic water flowing into the gulf, and provide full opportunities for definitely determining the old questions of the connection between the polar water (coming southwards along the coast of Newfoundland) and the Atlantic and the gulf of St. Lawrence water.

The investigation would further give important information regarding the spawning areas of the most important fishes, inside and outside the gulf of St. Lawrence, and determine hydrographical and biological conditions in this great fishing area. This contemplated plan will, in any case, in its main lines be the basis for

work during the coming summer. It is still uncertain if circumstances will allow it to be carried out to its full extent. Some parts, as for instance certain of the proposed lines for hydrographical and biological work, may have to be omitted should the necessary assistance of ships required not be available, but the expedition will, as far as circumstances allow, aim at the full undertaking of all the work proposed, and preparations for the equipment of the ships (gear, instruments) are now in progress.

Before the commencement of the expedition, it seems advisable to give a short review of the results already obtained by the study of the material collected during the year 1914. It is evident that these results can only be regarded as preliminary. The material to be collected during the coming season will, it is hoped, give a much wider basis for the discussion of the problems, the solution of which is now to be attempted, and a final statement will therefore have to wait till further material has been secured and the whole question considered in its entirety. But in the meantime it may be of value also for those who are taking part in the expedition to become acquainted in a preliminary way with the results of the material which has been studied already. The material now before me may throw some light on the following problems concerning the natural history of the herring:—

1. The racial characters of Canadian herring.
2. The age and growth of herring.
3. The fluctuations in the year-classes of herring.

I will in the following pages treat each of these problems separately.

1. RACIAL CHARACTERS.

The fishermen have in course of time made the observation that the herring are not everywhere of the same sort; that different sizes and qualities appear at different times, and in different parts of the sea. This led many to conclude that there are in the North Sea, for example, a great number of different local races of herring, each with a very restricted area of movement, and that the peculiar seasonal occurrence is only due to the fact that the fish, during the period of development of the genital organs, congregate in denser schools, rendering fishery operations profitable. Between the two extreme opinions, that of a great migration, and that of a number of local races, various other theories have arisen, and there exists a considerable series of works dealing with the different hypotheses. Scientific writers on the subject have, also, ever since the time of Linnæus, distinguished between different races or varieties of herring. There has, however, as Lilljeborg observes, always been a difficulty in classifying them according to definite and constant characteristics. In the earlier literature on the subject, we find several attempts at establishing a sharper distinction between the races by means of measurements and figures. Thus Nilsson attempted to calculate different physical dimensions, in proportion to the total length, for several races of herring, and to compare these proportions as between different races. He calculates in the case of the ocean herring (*forma oceanica*) that the longitudinal diameter of the eye amounts to from one twenty-second to one-twentieth of the total length (to base of tail fin) whereas the corresponding figures for the coast herring (Skjærgaardssild; *forma taenensis*) are only from one-seventeenth to one-sixteenth.

This method of distinguishing between different races by measurement of the dimensions of the body has, as is generally known, played an especially important part in the study of the races of mankind (anthropometry)) and the attempts which have been made to find some arithmetical expression of such minor racial peculiarities as lie at, or beyond, the limit of immediate visual perception, or are subject to so great a degree of variation that extensive observations are necessary in order to discover the average and the distinguishing characteristic for each separate race.

It is to Heincke that credit is due for first applying to the study of the herring all those principles and methods which have gradually been discovered and found of value for the study of mankind

The term "race" (family or tribe) is taken by Heincke to mean a number of individuals living together under the same external conditions, together propagating their kind, and standing therefore in more or less close relation to each other. The idea of a race is based upon that of an ideal type. All the separate individuals diverge from this type, both as regards each single quality and also, in each case to the combination of all the qualities appertaining to the type. The very idea of a type presupposes a certain degree of variation in the individuals and in their features, the type being the average or mean of all the different individual varying features.

Heincke's method is therefore to examine the individuals with regard to all, or a large number of qualities, and to find an arithmetical expression for a combination of these. In this way, the individuals of one and the same race will naturally group themselves about the same type (the mean of the race), and individuals of different races be separated, owing to the grouping of their qualities about different means. (Metode der kombinirten Merkmale.)

Working on this basis, Heincke has examined the variation of a great number of features in thousands of herring from different localities. Of the features in question some are constant, i.e. independent of the age and growth of the fish; to these belong the number of vertebræ, of keel scales, and of fin rays. By far the greater number of features which Heincke has examined have, however, been found to vary with age and growth. As Heincke himself points out, only a part of the investigations made can therefore be regarded as sufficiently exact and adequate. On the basis of all his investigations, Heincke has drawn up a system, the features of which we may notice as follows, taking especially into consideration the characters, which Heincke himself regards as the constant ones, i.e., number of vertebræ and number of keel scales:—

1. Northern ocean herring; spawn near the coasts in winter or spring, but move during summer in the open sea.

(*a*) Iceland herring of large size, mostly over 300 mm., when at maturity, number of vertebræ large, averaging over 5.7; number of keeled scales behind ventral fin (k_2) small, averaging under 14; tail tolerably long, head short and broad.

(*b*) Spring herring of Norway, large in size, at maturity over 300 mm., number of vertebræ very large, averaging over 57·5, single examples up to 60; number of tail vertebræ large, average 14·5 and more; average number of keeled scales under 14·5.

2. Coast herring; these are always winter spawning; they live in the immediate neighbourhood of the coast, spawning in brackish or estuary waters, differing greatly in different waters.

3. Ocean herring of the North Sea banks; inhabiting the open waters, from the coasts of England and Scotland across the whole North Sea. In summer and autumn they move to seek spawning grounds on the sandy and stony banks, which rise from the depths of the sea, and some distance from land. These have all a medium number of vertebræ (56·5 to 55·5); a large number of keel scales behind the ventral fins (15 to 14), these scales being highly developed. They have a broad skull. The southern bank herring have an extraordinary number of keel scales, 15 on an average to 17 and 20 in individual cases.

4. Autumn or sea-herring of the Baltic; size 250 mm., but towards Ruegen and Gotland bank growing less to 220 and 210 mm. Number of vertebræ small, 56·0 on an average, number of vertebræ to first hæmal arch 25·0 and more; number of keeled scales moderate 14·0 to 14·5.

5. Spring herring of the Baltic. Size less than 200 mm., number of vertebræ 55·5 to 55 on an average; keeled scales behind ventral fins, also small in number, the highest, 14·0 going down to 13·5 or less, number of first vertebræ with hæmal arch in contrast to small number of vertebræ very high, on average 25·0.

6. Herrings of English Channel. Size medium, probably on an average not over 250 mm., number of vertebræ small, 56; number of keeled scales behind ventrals very large, 15 and more.

7. Herrings of the White Sea. A very distinct race, size moderate; number of vertebræ very small, only 53·6 on average and descending even to 52; very small number of keeled scales, 12·5 behind ventral fins.

To this system there seems to be some general law for the development of the different types. Thus as the salinity of the Baltic diminishes from west to east, the constitutional size of the "ripe" herring becomes smaller, as does the number of vertebræ, and the breadth of the skull, the body becomes shorter; the lengths of head and tail become greater, and so does the difference in position between the dorsal and anal fins.

Again, those herring which grow in very warm, shallow and brackish water, as those of Schley and Zuider Zee, have an extremely small number of vertebræ to the post-hæmal arch. And again, the herring with the most considerable constitutional size, and likewise the largest number of vertebræ, live on the coasts of the northern portions of the North sea, and of Norway and Iceland.

Many investigations of more recent years have confirmed Heincke's investigations, i.e., the Norwegian investigations carried out by Dr. Hjalmar Broch. Of special interest are the following features in his description of a peculiar type of herring from the inlocked Beitstadfjord, a part of the Trondhjemsfjord. This type resembles the Norwegian coast herring, but has a smaller number of vertebræ (56·48 on an average); the number of the first vertebræ, with hæmal arch, is 25·09; the keel scales (behind the ventrals) 13·58, while these numbers for the coast herring are 57, 60, 25·05, and 14·07.

The investigations of herrings from the Atlantic coast of Canada are yet of a quite preliminary nature, but they already show, nevertheless, some features of great interest. I found it necessary to confine the work to some of the many characters which Heincke has studied, and I selected the following, which also are regarded by Heincke himself as the most important ones:—

Number of fin rays in the dorsal fin.
Number of fin rays in the anal fin.
Number of keel scales behind the ventrals.
Total number of vertebræ.
Number of first vertebræ with hæmal arch.

For the study of these characters, a series of samples (each consisting of from fifty to seventy-five individuals) were selected from the following localities:—

West coast of Newfoundland .
Magdalen islands, Northumberland straits, Gulf of St. Lawrence.
West Ardoise (Cape Breton, Atlantic coast).
Lockeport (Nova Scotia, Atlantic coast).
Bay of Fundy.
Gloucester, Massachusetts.

The investigations were made with the kind assistance of Dr. A. G. Huntsman and Mr. Horne Craigie of the University of Toronto. Table No. 1 contains the figures embracing the averages of the characters mentioned above for these samples, and the table gives in addition some details concerning the average length, percentage of the sexes, stages of development of sexual organs in individuals, etc.

TABLE No. 1.—Samples, investigated regarding race-characters.

—	West-Coast, N.F.	Magdalen Islands.	Northumberland Straits.	West Ardoise, N.S.	Lockeport, N.S.	Bay of Fundy.	Gloucester, Mass.
When caught	Fall 1914	May 1914	21 May 1914.	10 August 1914.	Fall 1914	Fall 1914	Fall 1914
Number of ind	75	55	52	55	50	54	50
Average lenghts	30·5	30·2	29·42	29·48	28 24	18·8	17 2
Per cent of ♂	41·3	45·5	39·1	68·6	50	?	?
Per cent of ♂	58·7	54·5	60·9	31·4	50	?	?
Average stage of sex. org	3-4	·5	5	4-5	5-6	1	1
Average of fat	†	0	0	1	0		
Fall (F.) or Spring (S) Spawners	S	S.	S.	F.	F.	F. (?)	F.
Average number Dorsal rays	20	18·3	18·27	18·58	20·28	18·7	19·9
Average number Anal rays	17·9	16·6	16·7	17·33	18·46	17 6	18·1
Average number Keel Scales	12·6	12·54	12·5	12·85	12·88	14·08	13·4
Number of first vertebra with closed normal arch	25·	25·3	25·2	25·5	25·2	25·	24·8
Total number of vertebrae	56·83	56·52	56·27	56·63	56·54	56·46	56·68

The herrings from the west coast of Newfoundland are spring spawners. The sample collected in the fall, 1914, had therefore sexual organs in development (stages 3 to 4, and medium development of fat). They were of large size, varying from 28 to 34, average 30·5. Number of dorsal fin rays varied from 18 to 22, average 20: anal fin rays from 16 to 20. average 18; keel scales from 11 to 14, average 12·6; total number of vertebræ from 55 to 59, average 56·83; first vertebræ with hæmal arch, average number, 25.

The sample from Magdalen islands, caught in May, 1914, consisted of spawning individuals from 27 to 32 cm. in length, average 30·2. Number of dorsal rays from 17 to 20, average 18·3; anal rays 15 to 18, average 16·6; keel scales 11 to 14, average 12·54; vertebræ 55 to 58, average 56·52; number of first hæmal vertebræ, 25·3.

The Northumberland Strait herring, caught in May, were also spawning; length from 27 to 33, average 29·42. Number of dorsal rays from 16 to 20, average 18·27; anal rays 15 to 19, average 16·7; keel scales 11 to 15, average 12·5; vertebræ 55 to 58, average 56·27; first hæmal vertebræ, number 25·2.

The sample from West Ardoise (Atlantic coast of Cape Breton) consists of individuals from 26 to 35 centimetres in length, average 29·48. The sample was caught on the 10th of August, 1914, the genital organs were developing (stages 4 and 5), which shows that these would have spawned during the fall. Dorsal rays 17 to 20, average 18·53; anal rays 15 to 19, average 17·33; keel scales 12 to 14, average 12·85; total number of vertebræ 55·58, average 56·63; first hæmal vertebra, number 25·5.

The sample from Lockeport (Atlantic coast of Nova Scotia) contained individuals from 25 to 34 centimetres of length. The sample did apparently consist of a mixture of mature and immature individuals, the stages of the sexual organs being as follows:—

Stage 2 (immature): 4.

Stages 5 and 6 (spawning or near spawning): 23.

Stage 7 (spents): 13.

The sample was taken in the fall, 1914, showing that the herrings spawn in the fall. Dorsal rays 19 to 22, average 20·28; anal rays 17 to 21, average 18·46; keel scales 11 to 14, average 12·88; total number of vertebræ 55·57, average 56·54; first hæmal vertebra number 25·2.

Bay of Fundy.— A sample of young immature herrings from 16 to 22 centimetres of length with genital organs so small that no conclusion can be drawn as to their spawning time. Dorsal rays 18 to 20, average 18·7; anal rays 15 to 20, average 17·7; keel scales 13 to 16, average 14·1; total number of vertebræ 55·57, average 56·5; first hæmal vertebra number 31·7.

Gloucester, Massachusetts.—A sample of small herring (13 to 22 cm.) taken in December, 1914, with immature genital organs. Dorsal rays 18 to 21, average 19·9; anal rays 16 to 20, average 18·1; keel scales 12 to 17, average 13·4; total number of vertebræ 55·58, average 56·68; first hæmal vertebra number 24·8.

While the foregoing figures are worthy of very careful study, yet the difficulty cannot be ignored that the investigation was essentially of a preliminary character, and it is possible that the material obtained was not sufficient to decide with certainty its full representative character. The quantity may not be sufficiently large to be regarded as representative or typical of the schools of herring from which the samples were taken.

No opinion can of course be made from *a priori* considerations; experience and continued investigation are the only means of arriving at a final and reliable conclusion in this matter. It will be noticed that the samples examined have been limited to about fifty in each sample. The reason for this was that the varying factors in most cases show a comparatively very narrow amplitude of variation (four or five classes). The results obtained seem to demonstrate that the method adopted gives corresponding results, but I wish nevertheless here to emphasize: first, that the results will have to be regarded as tentative and preliminary; and, secondly, that they ought to be confirmed during the work of the expedition before us. For this purpose it is valuable to consider the figures more thoroughly and try to ascertain what further investigations would seem of greatest interest and importance.

The first result yielded by the figures given above, and by table 1, is this: that there is a marked difference between the spring-spawning types of the gulf of St. Lawrence, Northumberland strait, Magdalen islands, and the west coast of Newfoundland, and the herrings from the Atlantic open coast (Cape Breton and Nova Scotia). This is already well known from the experience of men engaged in the Atlantic fishing industry; spring spawners being caught everywhere in the gulf, fall spawners off the Atlantic coast. According to information, which I have obtained, through interviews with the fishermen, the limit dividing the spring spawners and the fall spawners has to be drawn in an easterly direction through a point along the coast of Cape Breton at its northern shore (at the entrance to the gulf of St. Lawrence). North of this line all herrings are said to be spring spawners. South of the line the oceanic types are all of them fall spawners, but besides these types there are known to exist local spring spawning coast herrings as, for example in the bay of Fundy and around the coasts of the southern part of Nova Scotia. This is confirmed by the early investigations of Gilpin,[1] who observes that he has seen spawning herrings both in May and in September and October. From the Digby basin (bay of Fundy) he observes: "The first herring that make their appearance in the basin come there the last of March and the first of April; about the first of May they begin to spawn, and by the 20th May they have mostly left the harbour. On the Atlantic coast of Nova Scotia he has observed a shore run, about 11 inches in length, appearing early in March, and spawning in September and October." This would correspond to the conditions in the North Sea where there are herrings, coast herrings spawning in the spring, and oceanic herrings spawning at the outer banks, (e.g. Dogger bank) in the fall, but my material gives no opportunity for a proper description of these interesting varieties, which should be subjected to more thorough examination. The average figures given in the table, page 10, show, on the whole, small differences only between the different samples. There are no very striking differences to be observed in the

[1] J. Bernard Gilpin, "On the common herring (*Clupea elongata*)." Proceedings and Transactions of the Nova Scotia Institute of Natural Science, vol. 1, 1863.

characters of the different schools, from which the samples were taken. This much may, in any case, be noted:—

1. There is a marked difference in the number of keel scales between the northern spring spawners and the southern fall spawners. The average for the first group being about 12·5, the number for the second group increasing to 13 to 14.

2. The total number of vertebræ is highest in the sample from the west coast of Newfoundland (56·83).

3. Amongst the three spring-spawning types the number of vertebræ of the dorsal and anal rays, and of the keel scales is higher in the sample from the west coast of Newfoundland than in the samples from the southern part of the gulf of St. Lawrence.

4. The number of dorsal and anal rays is higher in the individuals caught in the open sea than in those from the closed waters (the gulf and bay of Fundy).

If we compare these samples from the American Atlantic coast with the samples which have been studied in European waters, we note, first of all, the very low number of keel scales in the northern samples from the American side; while the oceanic herrings of Northern Europe have an average number of keel scales (behind the ventrals) 14, 14·5, and even 15, all the samples from the gulf of St. Lawrence show an average number below 13, and near 12·5. Such a low average has in European waters only been observed from the Baltic and the White Sea, that is from inclosed waters with a very low winter temperature and low salinities. It is in this connection interesting to note that the number of vertebræ, of fin rays and of keel scales decrease in the series: west coast Newfoundland, Magdalen islands, Northumberland strait, just as these corresponding figures decrease in Norwegian samples collected from the open coast to the head of long enclosed fjords (Beitstadfjord, see above).

The herrings from the west coast of Newfoundland, which in other respects, such as their rate of growth, very much resemble the herrings of the Norwegian coast, have no such high number of vertebræ (57 to 58) as the Norwegian herrings, but I must draw attention to the fact, that my material does not contain any samples from the eastern shores of Newfoundland and from Labrador. These should be obtained and studied before any final conclusions are drawn in this respect.

On the whole, if the material before us does not give any conclusive and final determination of the racial characters of the herring types off the Atlantic coasts of North America, it does at any rate indicate:firstly, a marked racial difference between northern and southern types; and secondly, a difference between the racial characters of American and European herrings.

AGE AND GROWTH.

During the international investigations of the fisheries of northern Europe, methods have been developed for the study of the age and growth of the most important food fishes. The old discovery, that the bones and scales of these fishes show rings which very closely correspond to the growth of the fishes during the different seasons, has again attracted the interest of a great number of scientists, who have been able to prove[1] that the rings very closely correspond to the growth of the fishes, not only so, but the number of rings corresponds to the number of seasons (summers and winters) during which the fish have lived, and so complete are these features that the size of the rings, or zones, gives exact information with regard to the question as to the rate the fish has grown in the different periods of growth.

The investigations of Mr. Einar Lea have shown that the herrings of the Norwegian west coast mainly grow during the months from April to September; at the

[1] For the literature on this subject I may refer the reader to my paper quoted above.

most rapid rate during the three months May to July, while, in the winter, practically no growth whatever is indicated (see fig. 1, which is copied from Mr. Lea). This

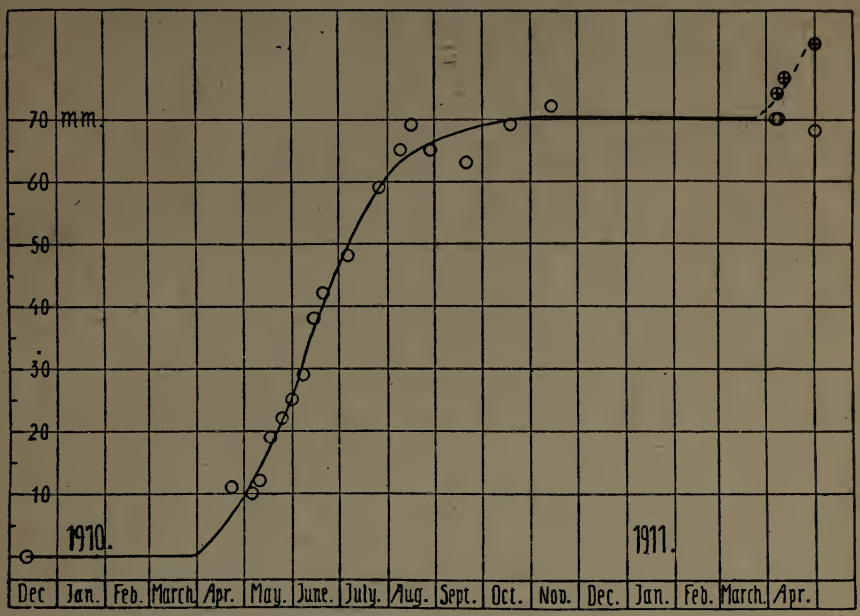


Fig. 1. Diagram illustrating the average increment of the herrings of the west coast of Norway in their 3rd growth period, between December, 1909, and March, 1911 (t_3). The broken curve denotes increment in the 4th period of the herrings (t_4). (LEA.)

shows the winters marked on the scales by sharp lines, while the growth of the summer appears as broad belts. If we now draw a picture of a scale, enlarged to such a degree as to make the distance between the centre of the so-called basal (horizontal on the figures) line to the edge of the scale equal to the length of the fish (see fig. 2) then

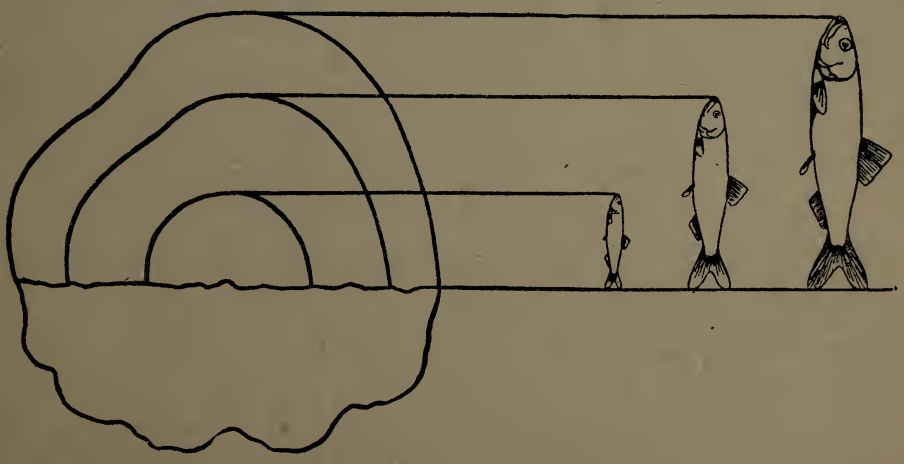


Fig. 2. Growth zones of herring scales compared with the size of fish.

the distances to the different winter rings will immediately show the size of the fish during each winter of its life.

In order to avoid the arduous work of drawing the scales thus enlarged, a labour-saving method is adopted as follows: With the aid of a prism, the microscopic picture is thrown on to a piece of paper on the table beside the microscope. On this picture a slip of paper is laid, upon which are marked off the different distances from the centre of the basal line to the annual rings (see fig. 3 V_1,v_1 and v_2). By means of

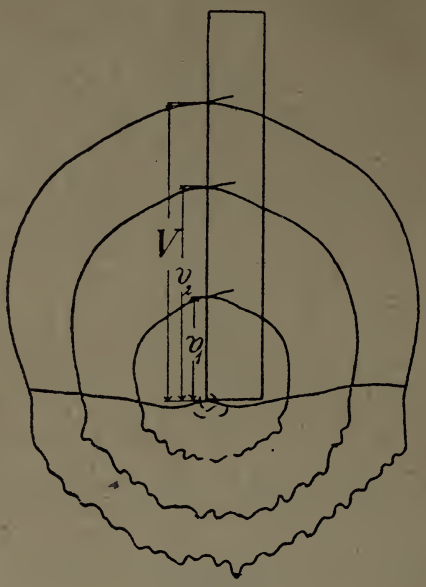
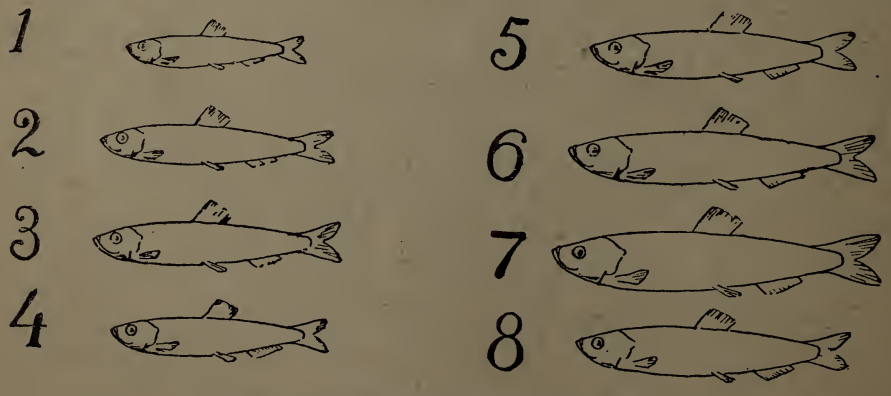


Fig. 3.

a special apparatus, it is then easy to calculate the length of the fish during the different winters.

During the international herring investigations, some thousands of fish from different waters have been measured according to these methods, and calculations made as to the size of the individuals, at the different periods of growth through which they have passed, thus furnishing a very large number of figures for calculation of the average growth of the herrings in different regions.

Some examples will show what can be attained by such investigations. Fig. 4



Flg. 4. Eight herring of equal (4 years) age from

1. White Sea.
2. Lysefjorden (West Norway).
3. Zuider Zee.
4. East Coast of Sweden.
5. Western part of North Sea.
6. Atlantic Ocean.
7. Iceland.
8. West Coast of Norway (Spring herring).

shows eight fish, all of equal age, viz. 4 years, but from different localities. All are drawn to the same scale and in the size representing the average for their respective localities. The drawings for this and the following figure are taken from two plates prepared by Lea for the Copenhagen Expedition, 1912.

The four races on the left (1 to 4) have their origin in closed waters, whereas the four on the right (5 to 8) were taken in the open sea (North Sea, Arctic ocean, Atlantic ocean). It will at once be seen that the herring from the closed waters are smaller than fish of the same age from the more open waters. Precisely the same impression is obtained on examination of the scales, as shown in fig. 5. These scales

Fig. 5. Normal scales of 5 year old herring from

1. Lysefjorden. 2. Zuider Zee. 3. Kattegat.
4. Faeroes. 5. Iceland. 6. Norway (Spring herring).
7. Western part of North Sea. 8. Atlantic Ocean. 9. Shetlands.

illustrate the growth of 4-year old herring from the localities in question. The scales are drawn in proportion to the size of the fish, while the distances between the different winter rings show how they have grown from year to year. A glance at the figure will show that the study of the scales furnishes information not only as to the different waters, but also as to entirely different modes or rates of growth in the periods embraced. Some show meagre growth until the formation of the first winter ring (1 and 2), while others show more rapid growth (3). Some have grown well in their first years, but less favourably later (7 and 8) while others exhibit very satisfactory growth even in their fifth year (5, 6 and 9). The growth may thus exhibit variations so considerable that it is frequently possible, in the case of a loose scale, to determine to what fish it belongs, even though other sorts may have been taken in the same haul.,

The material which has been collected from the North American waters, and which I have mentioned above, is now being studied by a similar method, and I shall here confine myself mainly to the results obtained from the study of the three great groups or types, which we have distinguished above.

1. From the Atlantic coast of Nova Scotia, containing oceanic herrings spawning in the fall, characterized by their large size.
2. From the west coast of Newfoundland, containing spring spawners.
3. From the Magdalen islands in the gulf of St. Lawrence, also spring spawners.

Before we try to compare these three types it will be necessary to go into somewhat greater detail concerning the methods for studying the variation of growth in

the different individuals of a type; and for the calculation also of the mean or average growth of the type. If we have a very large mass of observations upon the age of herrings of different sizes, it may, in many cases, be possible to find the average length of the herrings of each age (for each year's age). This is done by calculating the average length of all the different groups of equal age, e.g. of all the 4-years, the 5-year-old herrings, and so on. This same material can also be used for the study of the variation in length of all the 4, 5, or 6-year-old herrings. But the investigations of later years, especially the investigations of the Norwegian zoologists, Einar Lea and Oscar Sund, have shown that this method is not so reliable as one might anticipate, because the schools of herrings often consist of individuals which are not representative of all the individuals of the year-class to which they belong. A school of herring may contain only the larger individuals of the 4-year-old herrings, and an average of the length of these individuals may not represent the average length of all the 4-year-old herrings of the type living in the sea. The gear used for catching the herrings may also have a selecting power. All the smaller 4-year-old herring may go through the meshes, and the 4-year old herrings remaining in the net may, therefore, be far from being representative of the whole year-class.

Experience of this kind has led to the development of another method for the study of the variation and for ascertaining the average growth of fishes. We now examine the individuals of our samples, which belong to one single year-class of old grown fish from the spawning schools, these being so old that we may suppose that all individuals of the year-class have joined the spawning school. For each of the individuals of the year-class in the sample the length at the conclusion of the different growth periods is calculated, and these figures are then used for the study of the variation and average lengths exhibited by the year-class at different ages.

We will now briefly consider some figures obtained by the application of either of these two methods. The following tables (2 to 5) give some examples of the study of a series of samples by the first method, that is by the comparison of the length which herrings of the different year-classes had reached when the sample was taken.

TABLE No. 2.—Immature herring; Halifax Harbour, Fall, 1914.

Cm.	Number of different year classes.			All year classes.
	3	4	5	
23	1			1
24	1			1
25	1	6		7
26		28		28
27		12		13
28		8	1	8
29				0
30			2	2
All sizes.....	3	54	3	60
% All sizes.....	5	90	5	

Table 2 gives the analysis of a small sample of immature herrings from Halifax harbour. The sample consisted of 3, 4, and 5-year-old herrings. It will readily be seen that only the 4-year-old may have been represented in any such number that they could give us a key to the variation and average growth of the year-class. The variation is within the limits 25 to 28 centimetres of length, the average being somewhat over 26 centimetres.

TABLE No. 3.—Atlantic Coast of Nova Scotia, Fall, 1914.

Cm.	Number of different years classes.								All Year-classes.
	5	6	F.	8	9	10	11	Over 11	
29	1								1
30	1	2							3
31	1	4	3						8
32		2	6	1	1	1		1	12
33			5	3	3		1		12
34	1		8	7	10	5	2		33
35				4	25	10	2	3	44
36					2	5	8		15
37					1	2	3		6
38						1			1
All sizes.	4	8	22	15	42	24	16	4	135
p. c. of all sizes.	3	6	16·3	11·1	31·1	17·9	11·9	30	

Of the 3-year old only some few, apparently large individuals, were taken. The few 5-year-old belonged very likely to the smaller individuals of that year-class. Table 3 gives a smaller analysis of a sample consisting of 135 herrings from the coast of Nova Scotia. We find here some material of interest as far as the older year-classes are concerned, especially the 9, 10, and 11-year-old herring.

The 9-year-old vary between 32 and 37.
" 10 " " " 32 " 38.
" 11 " " " 33 " 37.

The younger year-classes are only represented by few individuals, and it seems uncertain if the individuals present have in any case been representative for the year class.

TABLE No. 4.—West Coast of Newfoundland, Spring, 1914.

Cm.	Number of Different year-classes.										All Year-classes.
	5	6	7	8	9	10	11	12	13	14	
27	1										1
28		1						1			2
29				1		2					3
30				1	3	7					11
31				2	9	18	5				34
32				5	13	13	7			1	39
33					3	7	5	2	1		18
34						3					3
35							1			1	2
All sizes.	1	1		9	28	50	18	3	1	2	113
p. c. all sizes.	0·9	0 9		8·0	24·8	44·2	15·8	2·7	0·9	1·8	

Table 4 gives the result of the study of some samples from Newfoundland. We meet here quite similar conditions; only the oldest year-classes seem to be represented by individuals of all sizes. Of the younger year-classes there are only a few individuals of all sizes. Of the younger year-classes there are only a few individuals which may belong to the larger part of their year-class. We find the 8-year old between 29 and 32, with an average of about 31 centimetres in length. The 9-year-old between 30 and 33, with an average between 31 and 32; the ten-year-old between 29 and 34; average a little over 31.

Table 5 contains an analysis of 151 herrings from the Magdalen islands. This sample shows some few younger (4 to 6-year-old) herrings. It seems very unlikely that the younger individuals are by any means representative of their respective year-classes. Better results are obtained by the second method described above, namely, by using the figures from the calculated lengths of the individuals in their different periods of growth. Tables 6 and 7 give the figures obtained by this method for the three different types of herring. Table 6 gives the limits of variation. The reader will here be able to see within which limits of size the herrings of different types have been found. Of great interest for our purpose is Table 7, where the figures are given for the average lengths in different ages and the average yearly increment of growth, as they have been found by the study of the three samples. In the table letters l_1, l_2, l_3, stands for the length of the herrings, when they were one, two or three years old (or rather when their first, second, or third winter ring was formed). The letters t_1, t_2, t_3, stand for the increment of growth, which the herrings have had during the respective years of their life.

TABLE No. 5.—Magdalen Islands, Spring, 1914.

Cm.	Number of Different Year Classes.									All Year Classes.
	4	5	6	7	8	9	10	11	Over 11	
25	1									1
26	1									2
27	5	1								6
28	4	1								5
29			4	4	4	1	1			14
30			4	6	9	7	7	10	1	44
31			1	6	6	6	9	15	4	47
32					4	3	3	13	4	27
33								2	2	4
34									1	1
No. all sizes	11	2	9	16	23	17	20	41	12	151
Per cent all sizes	7·3	1·3	6·0	10·6	15·2	11·3	13·3	27·2	7·7	

TABLE No. 6.

Age—Years.	Limits for variation in lengths (cm.) in different ages.		
	Nova Scotia.	Newfoundland.	Magdalen Islands.
1	8—14	4—11	8—11
2	16—22	10—21	15—20
3	21—27	16—25	21—24
4	24—31	19—28	24—27
5	27—33	22—30	25—28
6	27—34	25—33	27—29
7	30—34	25—33	28—30
8	31—35	27—34	28—30
9	32—36	29—35	29—31
10	32—36	31—35	29—32

TABLE No. 7.—Lengths (l) and Increments (t) of Herrings at Different Ages.

L.				t			
	Nova Scotia. E	N. F. w. c. —	Magd. Isl. M		Nova Scotia. E	N. F. w. c. K	Magd. Isl. M
l_1	11.05	6.6	9.73	t_1	11.05	6.3	9.73
l_2	18.55	13.7	17.2	t_2	7.5	7.3	7.47
l_3	23.5	19.2	22.47	t_3	5.45	5.2	5.27
l_4	27.2	22.7	28.25	t_4	3.7	3.7	2.78
l_5	29.65	25.3	26.75	t_5	2.45	3.0	1.50
l_6	31.15	27.5	27.87	t_6	1.50	3.0	1.12
l_7	32.25	29.0	28.74	t_7	1.10	1.1	0.87
l_8	33.4	30.2	29.2	t_8	1.15	1.4	0.46
l_9	34.15	31.0	30 53	t_9	0.75	0.6	0.80
l_{10}	34.85	31.7	31.2	t_{10}	0.70	0.9	0.53

A study of the table will clearly show that there is a great difference in the growth of the three types. The Atlantic herring from the coast of Nova Scotia (sample E.)

has all through a much more rapid growth than the two other types. The 1-year-old herring is over 11 centimetres (5½ inches long); the 2-year, 18½ centimetres (7½ inches long). It reaches 23·5 centimetres (9½ inches) at 3 years, 27·2 (11 inches) at 4 years, about 12 inches at 5, and nearly 14 inches at 10 years of age.

The herrings from the west coast of Newfoundland are especially characterised by slow growth during the first years of their life. In the first five years the Newfoundland herring are smaller than herrings belonging to the two other types, but from the fifth year on, their growth is more rapid than the two other years. The older Newfoundland herrings are therefore larger than the herrings from the Magdalen Island, and they approach without quite reaching the size of the equally old herrings from the Nova Scotian Atlantic coast. It is very characteristic of the Newfoundland herrings that their growth is greater even until a late period in life than is the case with the two other types. The Magdalen Island herring grow comparatively well during the first three or four years, but from then on the rate of growth is very small.

The comparison between these types will perhaps be rendered still easier by the study of figure 6, where the average growth (lengths) of the three types is represented

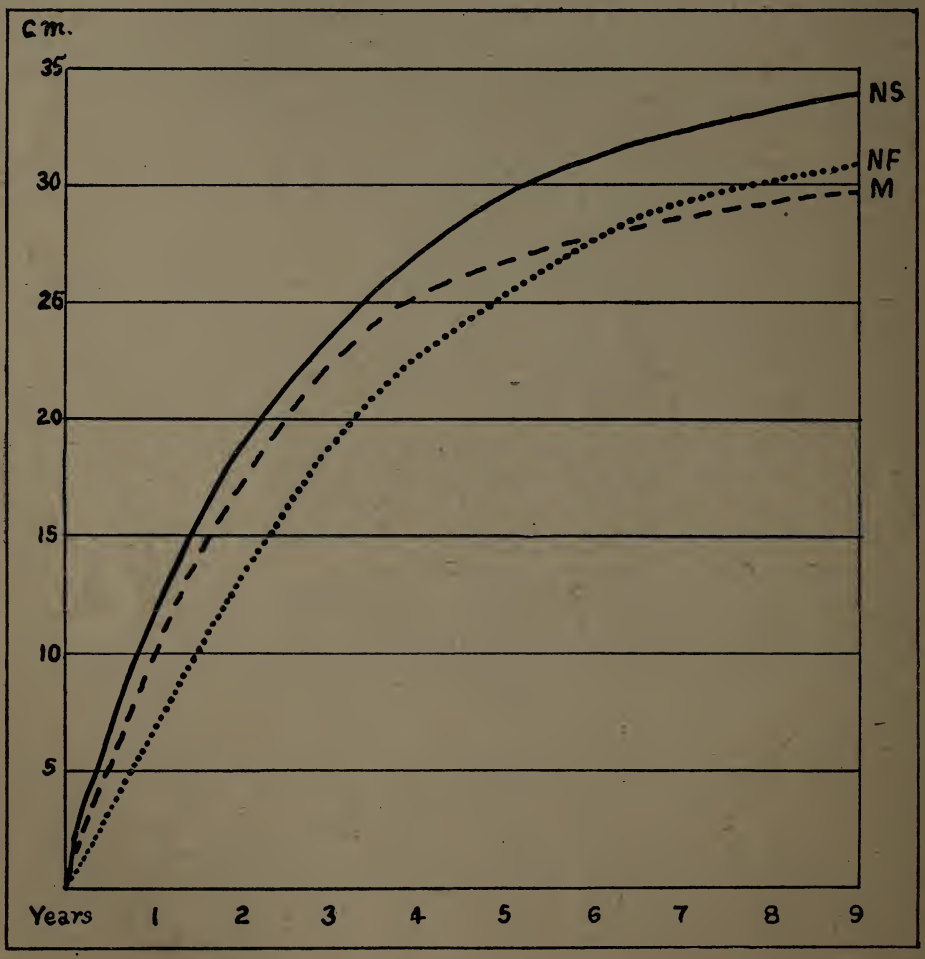


Fig. 6. Curves for the average lengths in different years of herrings from Atlantic Coast of Nova Scotia (N.S.) West Coast of Newfoundland (N.F.) and The Magdalen Islands (M.)

by three curves. The reader will observe that the curve for the Nova Scotia herring, through its whole length, lies above the two others, that the curve for the Magdalen Islands herrings first lies above and then crosses below the curve for the Newfoundland herring.

Similar results have been obtained by the study of herrings from the waters of northern Europe. Fig. 7 gives the typical growth of three European types, the one

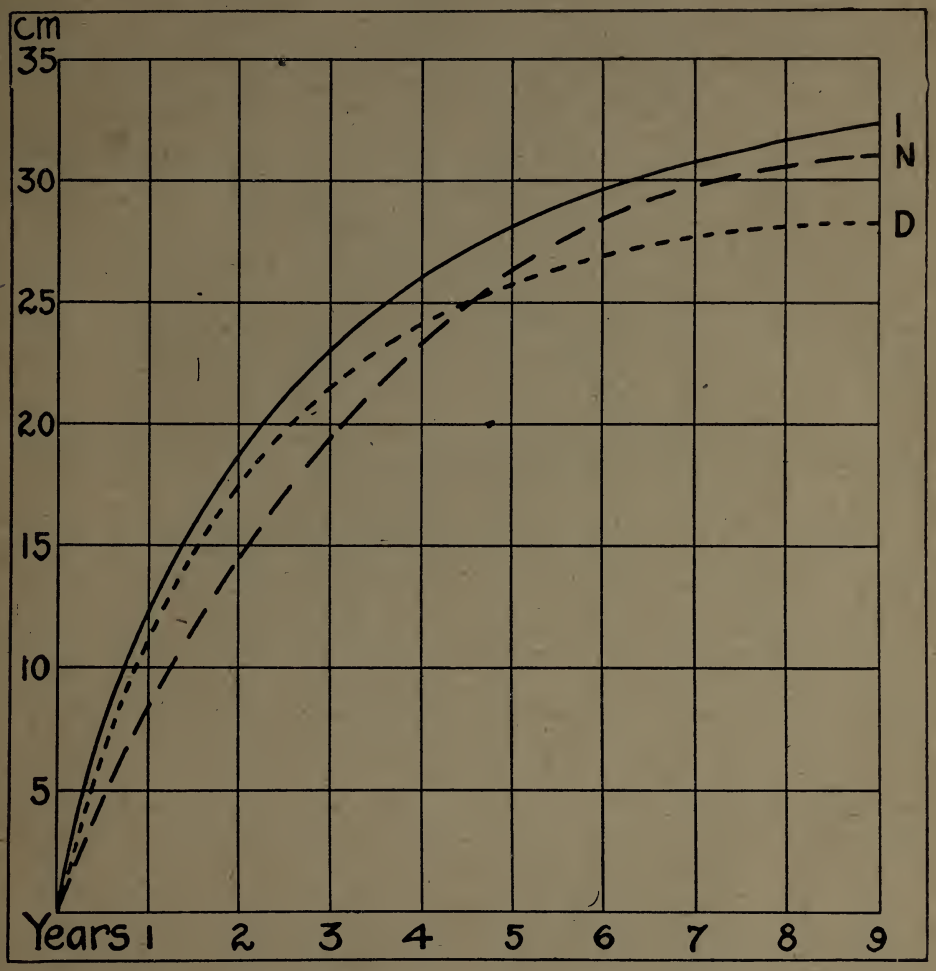


Fig. 7. Curves for the average lengths in different years of herrings from Atlantic Coast of Ireland (I.) West Coast of Norway (N.) and The Dogger Bank, Southern North Sea (D.)

from the west coast of Ireland, the second from Norway, and the third from southern North Sea, the Dogger bank. It will be observed that the growth of these three types differs in a manner quite corresponding to what we have described above for the three types from American waters. The growth of the herrings from the Atlantic open coast of Ireland is the greatest, the curve being always above the other two curves. The herrings from Norwegian waters show a slow growth in their first years of life, slower than the Dogger bank herrings, but the growth is very even up to the age of five or six years, it therefore surpasses the growth of the Dogger bank herring in later years, the two curves for these types cross each other, and the old Norwegian herring

approach but do not quite reach the size of the Atlantic herrings from Ireland of the same age. A comparison between the two figs. 6 and 7 should therefore indicate that there is a resemblance, with regard to growth, between the Atlantic herrings from Ireland and those from Nova Scotia; the west coast herrings from Norway and those from the west coast of Newfoundland; the North Sea Dogger Bank herrings and the herrings from Magdalen Island. It seems worth while to give this statement a more careful consideration. This may be facilitated by the inspection of the three figs. 8, 9, and 10. Fig. 8 gives two curves for the Atlantic herrings from Ireland and Nova

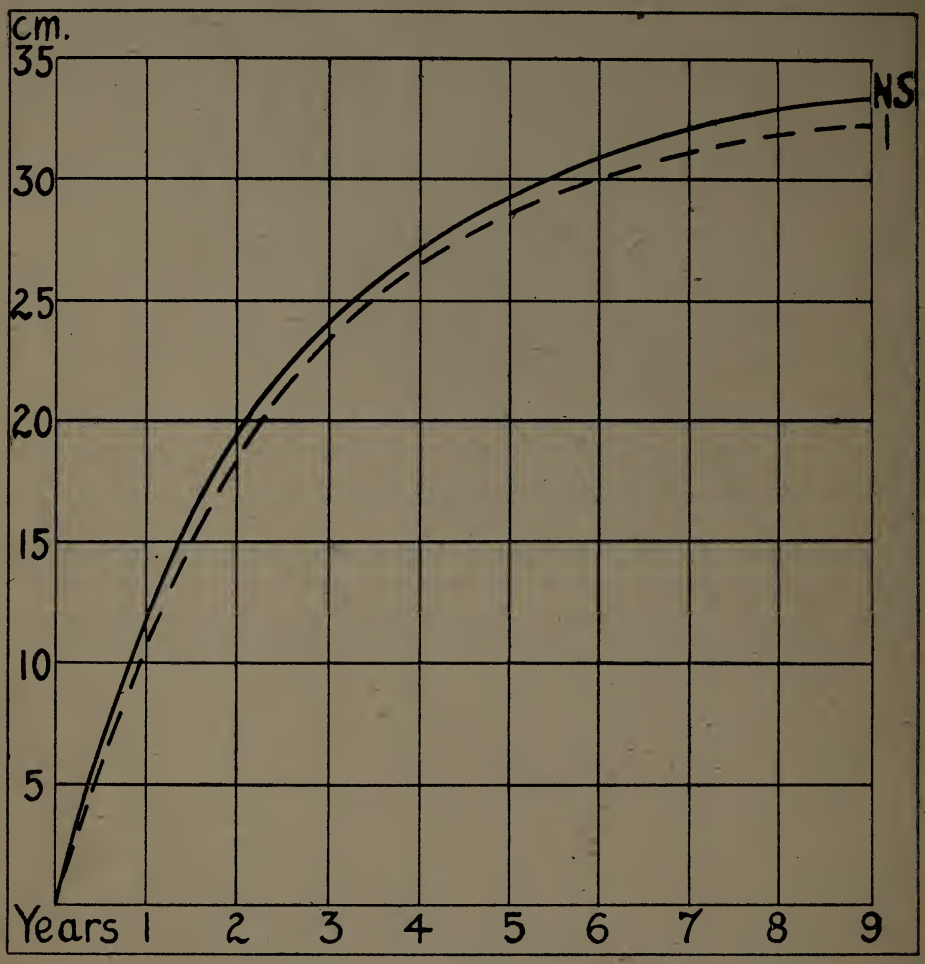


Fig. 8. Curves for the average lengths in different years of herrings from West Coast of Ireland (I.) Atlantic Coast of Nova Scotia (N.S.)

Scotia. The curves run quite parallel, and the distance between them is everywhere very small. Fig. 9 compares the growth of herring from Newfoundland, (NF) and Norway (N). We find also here a very great correspondence. The Newfoundland herring grow somewhat slower, but the difference seems to be very small. Fig. 10 compares the herring from Magdalen Islands (M) with the Dogger bank herring (D). These two types have the same characteristic in common, that their growth in the first years is very rapid but afterwards very slow. The Dogger bank herring grow less than the Magdalen herring in later years of life.

These differences in the different types are so characteristic that the mere inspection of the scales in many cases will suffice to distinguish individuals belonging to one

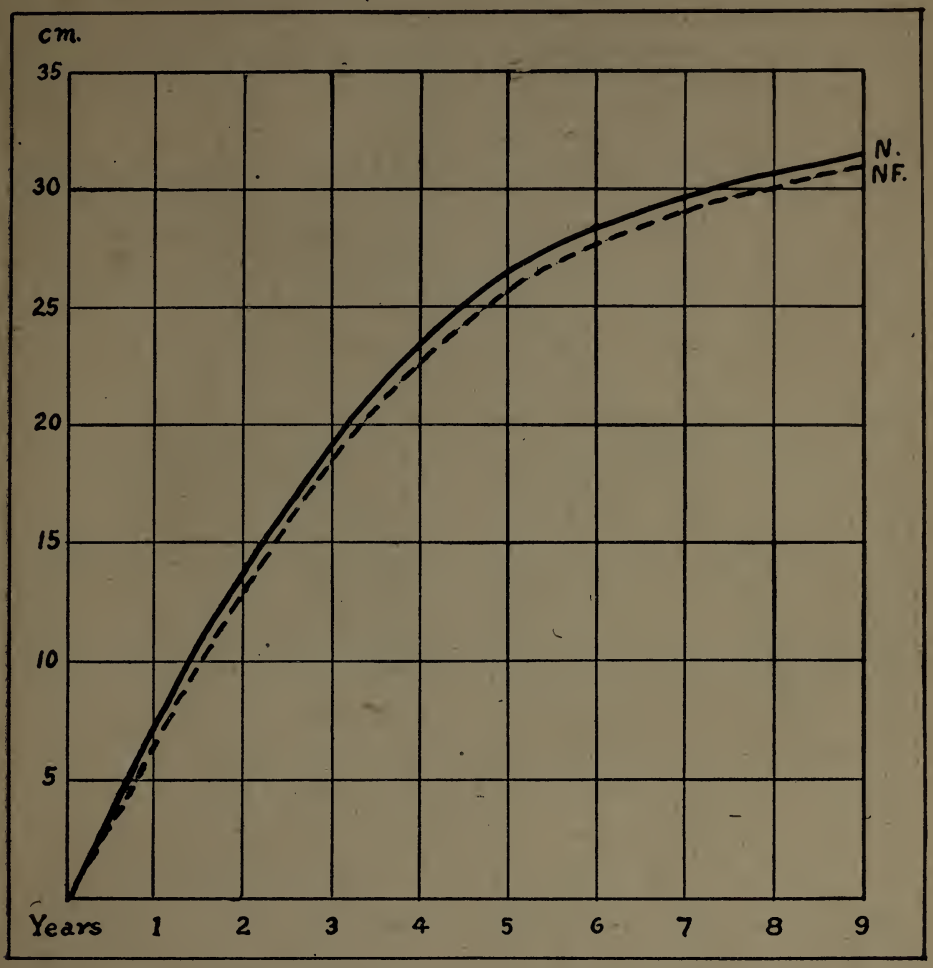


Fig. 9. Curves for the average lengths in different years of herrings from West Coast of Norway (N.) West Coast of Newfoundland (N.F.)

type from those of other types. To demonstrate this I have drawn the two series of normal scales of fig. 11. The series A, C, and E on the left side of the figure give the three types from the European side; the series to the right B, D, and F, from the American side. All these normal scales are drawn according to the rule, described above (text to fig. 5), that the vertical distances, from the centre of the basal line to the margin of the scales in all the drawings, correspond to the average length of the fish when nine years of age, while the growth zones represent the average growth of the types in the respective periods (years) of growth.

A comparison of these normal scales will clearly show a marked difference in rate of growth and in manner of growth between the different types of each series and, further, the great resemblance between the two series. Most marked is the difference between the Newfoundland herring and the Magdalen Island herring. This circumstance is very important as both these types of herring occur in the same sea (the gulf of St. Lawrence), though not in the same areas of that sea. In the sample of

the Magdalen Island herrings a few individuals were found showing a growth very similar to that of the Newfoundland herring, and the scales of these herring were so

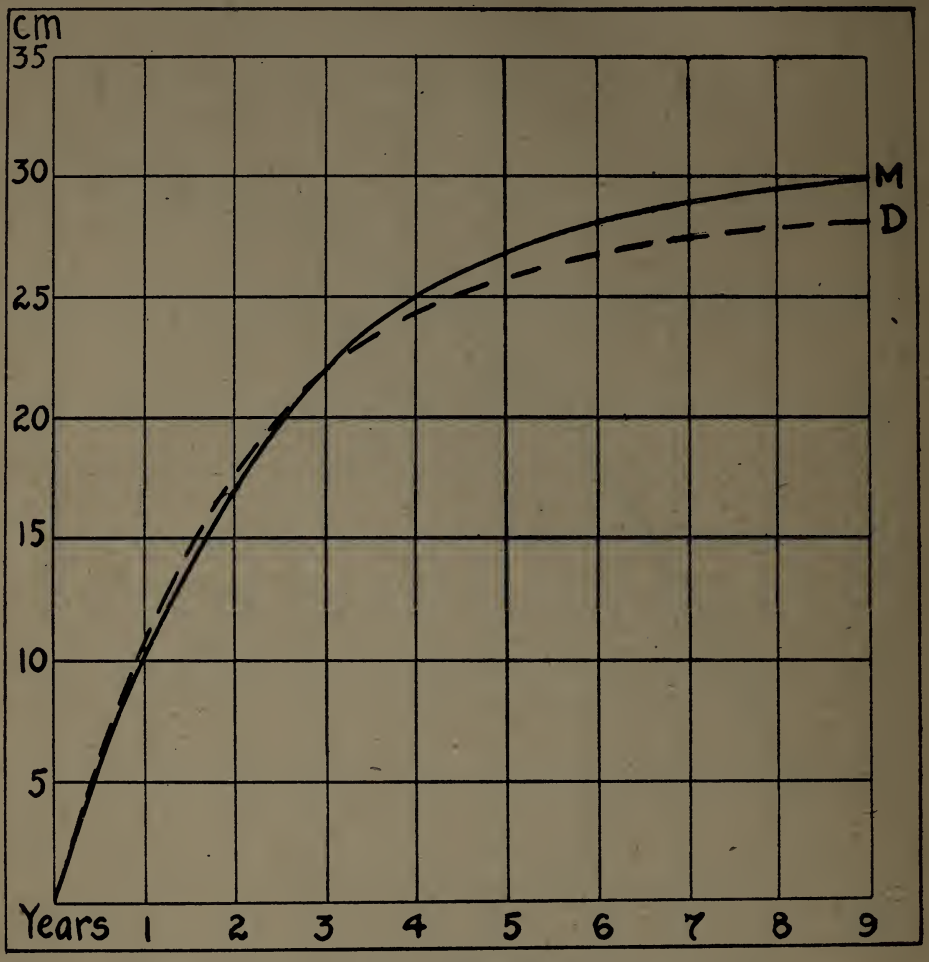


Fig. 10. Curves for the average lengths in different years of herrings from The Dogger Bank, Southern part of North Sea (D.) The Magdalen Islands (M.)

characteristic that they immediately revealed themselves clearly to the observer. In those areas of the sea where two or more very different types of herrings meet or intermingle to a greater or small degree, it may be possible, therefore, to ascertain the extent of the intermixing between the different schools, and the areas of distribution and migration of the different types. The gulf of St. Lawrence seems to provide the most excellent conditions for investigations of this kind.

The comparison between the different types of herring which I have tried to draw, raises the question "what conditions are the most important for developing this variation in the different types of herring?" To all biologists it will be clear that questions like these can only be solved by tests and experiments. Such experiments have never been made ,and they may not be expected in the near future. It will be necessary to overcome great technical difficulties, as the development of the animals not only through years, but through generations, will require to be followed. On the basis of our present knowledge we can only compare the conditions of the sea under which the different types live. The larger in amount our material is, and the greater

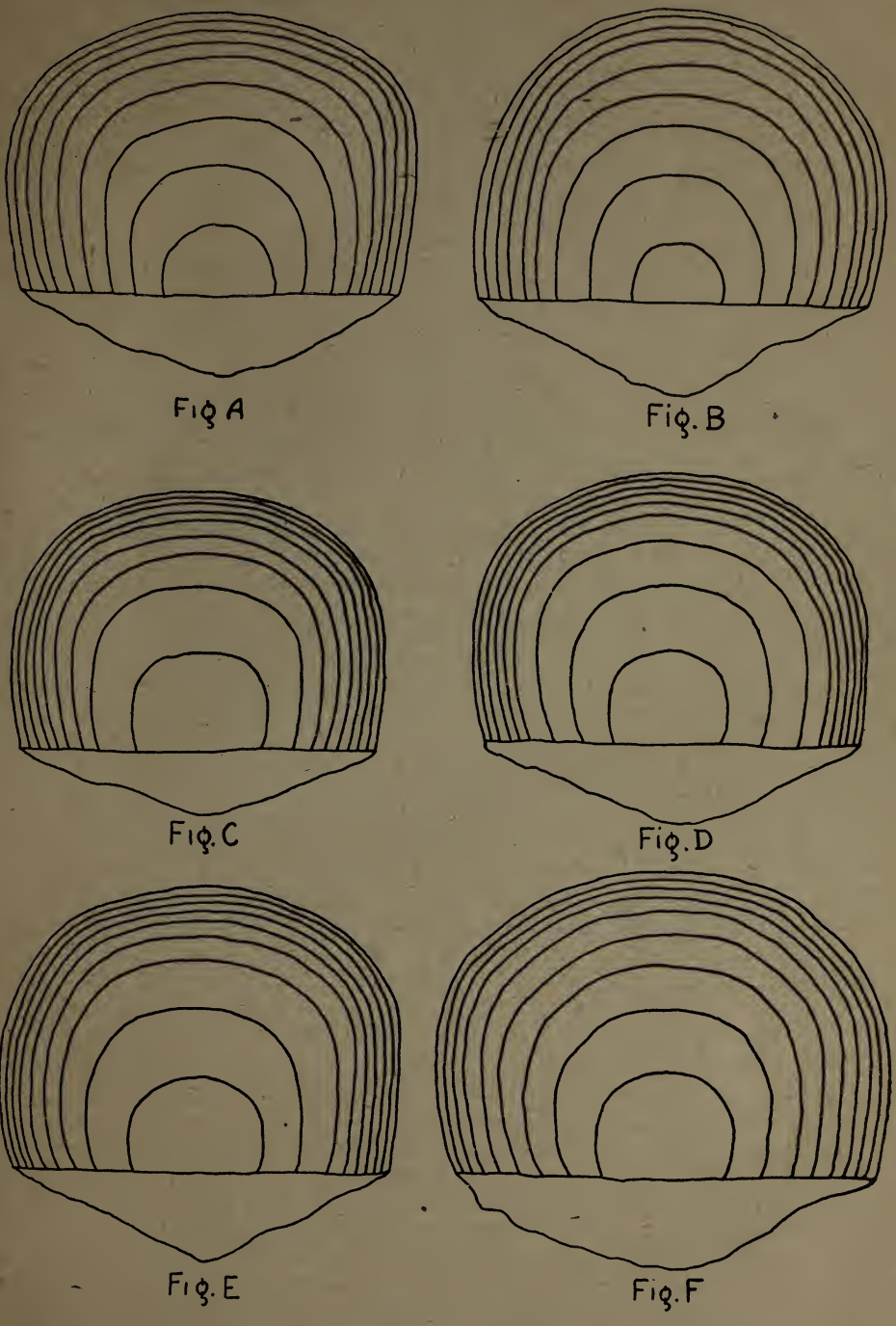


Fig. 11. Two series of normal scales of herrings. The left series from the waters of Northern Europe. The right series from North American waters.

A. Norwegian West Coast.
B. West Coast of Newfoundland.
C. Dogger Bank.
D. Magdalen Islands.
E. Atlantic Coast of Ireland.
F. Atlantic Coast of Nova Scotia.

the area of the sea is, which we have been able to investigate, the easier it will be for us to determine the conditions or environment under which a certain type everywhere occurs, but this method of geographical and biological comparison will nevertheless hardly ever reach the certainty of accurate scientific experiment.

It must in any case, be regarded as an important addition to our knowledge that the interesting series, or system of types, which have been determined by the investigations in Europe, now can be proved to have a close parallel both in regard to racial characters and with regard to rate of growth, on the American side of the Atlantic. This addition to our knowledge may therefore justify a few remarks regarding the conditions under which the different types live.

The Irish and the Nova Scotian herrings, distinguished by their excessive growth, their spawning in the fall, their high numbers of keel scales, both belong to the open Atlantic waters, these waters being marked by a high salinity and more limited changes in temperature during the different seasons.

The Norwegian and Newfoundland herrings also belong to the open sea, but the salt water is of less salinity and is mixed with cold fresh water from the land or from the Arctic sea. They live under a more marked boreal climate and amidst a typical boreal fauna. The difference between summer and winter is very marked in their surroundings, both with regard to temperature and biological conditions (food animals).

The herrings of the Magdalen islands live in the southern part of the gulf of St. Lawrence, where the fresh water from the St. Lawrence river lowers the salinity of the sea water, where the temperature in summer is high, in winter very low, where the water is shallow over the many banks of the gulf. The conditions, under which the Dogger Bank herring live, only to some extent correspond to these conditions in the southern part of the gulf of St. Lawrence. The southern North sea is shallow, its temperature is high in summer and low in winter, but never so low as in the gulf of St. Lawrence. The two areas must therefore in many respects be very different, to what extent it is difficult to ascertain at present, as little has been done to define the conditions in the gulf, conditions of the greatest interest from a biological point of view. This is one of the reasons for my proposal to combine the herring work of the coming summer with hydrographical and biological investigations of a wider character. When such investigations have been completed, it may be possible to establish a more satisfactory comparison between the herrings of the gulf and herrings from other parts of the ocean. In European waters there are several types of herrings all characterized by rapid growth in their first years, and by stagnant growth in the later part of their life. Such is the case in Skagerak, the Cattegat, the Baltic, the Zuider Zee, etc. It will be interesting to revive these questions when further investigations have been made.

It may in this connection be of interest to compare the growth of the so-called fresh-water herring (*Pomolobus pseudo-harengus,* Wilson), although this herring belongs to a quite different species. I have not been in the position to investigate a great number of individuals belonging to this species, but have, through the kindness of Dr. Huntsman, had the opportunity of examining a few specimens. The scale, fig. 12, is from a fish with seven rings inside the margin. The fish was caught in lake Ontario (at Port Credit) in the fall of 1913, nad was 24 centimetres long. Its lengths at different periods of growth were the following: l_1 8·5, l_2 16·3, l_3 18·7, l_4 20·2, l_5 21·6, l_6 22·8, l_7 23·7. It will be observed that this growth indicates a marked resemblance to the Magdalen Island and the Dogger Bank herring, viz., a rapid growth during the first years of life and a very slow or stagnant growth in later years.

3. THE FLUCTUATIONS IN THE YEAR-CLASSES.

During the international investigations of the fisheries of Northern Europe, discoveries have been made showing:—

1. That the stock of cod and herring includes a far greater number of year classes than previously had been supposed, and

2. That the relative numerical value of these year-classes exhibits great fluctuations from year to year.

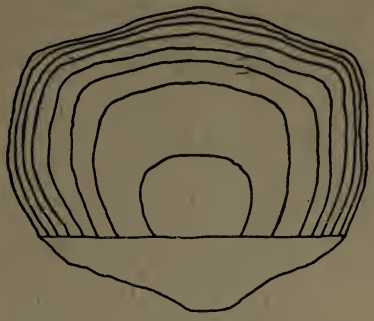


Fig. 12. A scale of a specimen of *Pomolobus pseudoharengus* (WILSON) taken off Port Credit, Lake Ontario, in the Fall 1913. The scale is drawn in the same magnification as the normal scales of fig. 11.

These discoveries resulted from the endeavour to subject the stock of these important fishes to a similar examination, and to such a survey as that universally adopted for the study of the human population (the vital statistics of a population). In a lecture delivered at the meeting of the International Council for the Study of the Sea, 1907, I endeavoured to formulate the programme for this work in the following words: "In all expositions of the science of vital statistics,[1] there are three prominent features which attract our chief consideration: (1) birth-rate; (2) age, distribution; (3) migration. It is customary to study these questions by the help of what are called representation statistics. A certain number of individuals are selected who are supposed to stand for the mass of the people, and attention is directed to them. We ascertain from this source their average length of life, their wanderings, their increase or decrease, and whether sickness, war, disaster, or emigration plays any appreciable part in reducing the population. It seems at first sight a bold suggestion to propose studying the fish supply on lines like these. A population can be counted, but who knows how many fishes are in the sea? And yet, it appears to me a project big with possibility, to regard the discoveries of fishery research from a standpoint similar to that which has been adopted in the science of vital statistics."

The methods and plan for investigating the stock of fishes along lines like these will best be understood by the consideration of examples of what has been accomplished already. Before I try to describe the first few investigations of the stock of herring from the Canadian waters, I will in spite of the risk of being obliged largely to repeat my previous publications, first give a short review of some of the results obtained through the study of the herring fisheries of Norway. I have previously described these fisheries in the following way: The herring fishery is carried on along the whole of the Norwegian coast, in the fjords, among the islands, and in the open sea off the shore. The fishermen use nets and seines, stake-nets which are anchored along the bottom or to floats, and drift-nets, which are fastened together in a chain, and drift with the boat or vessel at night. The seines cut off the shoals, either along the shore (shore-seines) or at some little distance from land (purse-seines). The nets used take only certain sizes of fish, according to the width of mesh, and nets with many different sizes of mesh are therefore employed, having regard to the kind of fish expected to be caught. The seines are of fine mesh, and can frequently take all herrings down to 7 or 8 cm. in length. It is very rarely, however, that all sizes of herring are found in one and the same haul. This is due to the fact that the different sizes of fish move in separate shoals, apart from one another. There are thus many

[1] See my paper quoted above.

different kinds of herring fishing carried on in the Norwegian waters, and many different "sorts" of herring are recognized, according to the size most common in the different shoals. These sorts have been known, both among the fishermen and in the trade, from time immemorial, and a great amount of care and study has been devoted to the question of dividing them according to some rational method of assortment.

The fishery statistics distinguish four principal groups: small herring, fat herring, large herring, and spring herring. It is also possible to distinguish, practically speaking, four different kinds of herring fishing, corresponding to these four classes, and differing, not only as regards the method of capture employed but also in point of place and time; these being carried on, for the most part, in different regions of the coastal waters, and at different periods of the year. In the year 1908, the catches of the different classes were as follows (given in hectolitres) see chart, fig. 13:—

—	Spring Herring.	Large Herring.	Fat Herring.	Small Herring.
West Coast	613,356	...	605	47,880
Romsdal	11,500	101,320	4,990	18,151
Trondelagen	.....	9,628	73,852	39,320
Nordland	.....	800	408,654	77,100
Tromso-District	.....	9	127,500	48,100
Finmarken	.....	.....	.....	92,580
Whole country	624,856	111,757	615,601	323,131

Whole country total of all sorts 1,675,345 hl.

The small herring are taken, as will be seen from the above, all along the coast, but in increasing numbers farther to the north. The fat herring are taken, by far the greater part, within the range from Trondhjemsjord to the Tromso district, the large herrings of the coasts of the Romsdal and southern Trondhjem district, while by far the greater part of the spring herring are taken in the west coast waters.

The small herring do not exceed 19 centimetres in length; they vary from 8 to 19 cm. The ovary or milt is, at the utmost, only visible as a thin thread below the spine; in point of fatness they are far inferior to the fat herring. Age determinations have shown that they belong to the three, mostly to the two first year-classes. The fat herring vary as a rule from 19 to 26 centimetres (7½ to 10½ inches), the genital organs of the lesser fish are very small, incipient development being noticeable in the case of the larger. The adipose deposit, however, in the flesh and round the intestines ("ister,") is much more developed than in any other class of herring. Age determinations have shown that the fat herring consists of fish from 3 to 6 years old. The large herring are superior in size, running as a rule from 27 to 32 centimetres; their genital organs are, from the autumn, in advancing development towards maturity. In the course of this development the adipose deposit gradually decreases in quantity, and the fish finally pass, by imperceptible degrees, into the class of spring herring, which are the spawning fish. Among these latter, the ovaries are in January firm, in February and March slack, and in April entirely spent, the fish at this time being also thin and in poor condition. According to the age determinations the large and spring herrings consist of the oldest from 3- to 20-year-old fish (*vide* below).

Small herring and fat herring are thus immature fish, the large and spring herring being mature. The maturity has been shown to develop at a different age in different parts of the long coast. In the southern part at an age of 3 to 5, mostly 4 years, in the northern part of the coast at 5 or even 6 years of age. The spawning shoals off the southwestern coast contain, therefore, individuals from the third year on.

The scientific investigations of the stock of herrings off the coast of Norway has, after the work of many years, yielded the following general idea of the life history of the herring in these Norwegian waters.

All the herrings of the open coast belong to one and the same race or type. By far the greatest number of native individuals of this race aggregate during the fall off the coast of Romsdal (see chart fig. 13), where they are called "large" herring

Fig. 13.

and caught by drift-nets in great quantities. The genital organs are then developing, and this developing condition or ripening continues during the winter months, when the spawning shoals aggregate at the west coast, where they are caught in gill-nets and seines as spring herring.

The young fry undergoing development in the ova laid on the sandy bottom of the inshore banks off the west coast escape soon from the eggs and are then carried northward along the coast by the current, which off the whole west coast has a marked northerly direction (the so-called Gulf Stream). They spread as if sown all along the extensive range of the coast, and everywhere these small fish undergo further development, without question, in northern waters. In the autumn when these small fry are 8 to 10 centimetres (below 4 inches), and two-thirds of a year old, they begin to make their appearance in the seines. Next year they reach a size of 12 to 15 centimetres (5 to 6 inches). These are the small herring which are caught along the whole coast (see table above).

In the third year they develop an abundance of fat, and remain in this state (mainly in the summer and fall) till the genital organs develop, which, as stated above, begins from the third, but mostly at the fourth or fifth year in the south, and mostly at the fifth and sixth year in the north.

The mature individuals then leave the fat herring shoals and begin to migrate southwards along the coast till they reach the large shoals of mature large herring, with which they intermingle.

Among these many different sizes of herring, from the young fry up to the mature and oldest fish, we find several groups, differing either in biological respects or in regard to habitat and manner of life. It is therefore impossible here (contrary to what may be the case in the study of the human population of a town or a country) to make at any one place or at any one time a selection from the individuals in the sea sufficiently representative to permit of immediate conditions as to the composition of the mass. In each catch made we find individuals, which may be representative with regard to size and age of the biological group (i.e., the mature herring) to which they belong, but not to the whole stock of herrings.

It is necessary, therefore, to take many samples from different shoals of fish at different places, endeavouring to combine observations resulting so as to form, as it were, a complete picture. Moreover, it is in some respects impossible to find any standard by which to judge of the respective quantitative values of the different groups, even though it may be possible to accurately determine the composition in point of size of each separate group. The investigations of the different (biological) groups of herring have, however, shown that repeated study from season to season can give a most valuable general idea of the variations and fluctuations in the preponderance of the different ages or year-classes within the different groups; e.g. within the fat herring and spring herring. The combined study of the statistics of the fisheries (the catches of the fishermen) and the fluctuation with regard to the year-classes, in the most important groups of herrings, have proved sufficient to demonstrate that the cause of fluctuations in the fisheries is to be found in the great fluctuations in the number of individuals occurring in the fish born or developed in the different years (fluctuations in the year-classes).

For a fuller proof of this statement, I may refer the reader to my publication mentioned above. Here I must confine myself to the most striking and important instance found in this direction, namely, to the fluctuation in the year-classes within the shoals of the Norwegian spring herring.

The spring herring of the Norwegian west coast have been studied in the years from 1907 to 1915. In each of these years samples have been collected from the seine catches of the fishermen, and the age of each herring in the sample has been determined by the methods described above. On the basis of this large amount of material, the percentage of the different year-classes represented in the samples has been calculated in order to get definite information as to the question: are different ages every year represented by the same numbers, or do fluctuations occur from year to year?

The results of all these age determinations for the years 1907-14 are given on fig. 15, where percentage curves are shown for each of the eight years. The curve for 1907 shows that there were in this year, no less than five fairly rich and fairly evenly represented year-classes (the 4 to 8-year-old fish). This even proportion is broken in 1908 by the appearance of a very great number of 4-year-old individuals (the summit of the curve) which, accordingly, were born in the year 1904, the 1904 year-class. In all the following years this year-class maintains a great preponderance over all the other year-classes. In 1909 the 5-year, in 1910 the 6-year, in 1911 the 7-year-old fish being by far the most numerous. It has been calculated that the Norwegian spring herrings in the years 1907-13 were caught to the number of 3,312,000,000 individuals, taken altogether, and that of this total no less than 1,776 millions belonged to the 1-year-class, the individuals born in the year 1904. The immense number of this year-class is further believed to have been the great cause of the rise in the Norwegian spring herring fisheries, which in the years 1908-13 (when the year-class in increasing numbers belonged to the spawning shoals) increased from 625,000 to no less than 1,500,000 hectolitres.

The extensive investigations of the Norwegian fisheries have further demonstrated that this same year-class of herrings played the greatest role also amongst the fat herring in the years (1907-10) when great numbers of the individuals of this year-class still were immature and belonged to the fat herring shoals.

Other investigations have shown that similar fluctuations in the different year-classes also take place in the stock of haddock and cod, and that the year 1904 had the same important influence regarding these species of fish. Immense numbers of young fish were produced which were of the greatest importance to the Norwegian fisheries, when they reached the age and size in which they are caught by the fishermen. The international investigations of the herring fisheries of the North Sea (the herring of the British coasts) have been summarized in the following words: "If we compare these results with the composition in point of age of the Norwegian race of herring, we find this similarity, that both races exhibit some remarkably rich year-classes, not, however, in both cases from the same year. There is probably also this point of difference, that the richness of these year-classes is more pronounced in the case of the Norwegian race than in that of the North Sea fish. The fluctuations in the herring fishery of the North Sea are therefore slighter than in those of the Norwegian waters."

From the point of view of the method of investigation, it must be regarded as a most striking and wonderful fact, that it is possible to collect a sample, say of some few hundred herrings, and then to find this sample really giving a representative picture of the composition, with regard to size and age, of the whole stock of incalculable millions of spawning herring in the sea. As I pointed out in my lecture in London, in 1907, before these investigations started, it seemed at first a bold suggestion to propose studying the fish supply along lines like these. A population can be counted; but who knows how many fish are in the sea? From the feeling of the magnitude and difficulty of the task, the scientists who took part in this work hesitated for many years before their definite belief in the representative character of the results grew so strong that they dared to regard the method and the results as sufficiently proved and fully established.

The essential question which had to be answered before this belief was strong enough to become a scientific conviction was, of course, this: "How large an amount of material was absolutely necessary to afford a representative picture?" We have during our work started from the point of view that no information could be obtained regarding this problem purely from theoretical or *a priori* considerations. No mathematician can calculate the number required for a representative sample of the Norwegian spring herring. This number depends above all on the question, how evenly mixed are the different sizes and ages in the stock of the spawning shoals, and the answer to this question can only be given through scientific tests and experience, that is, through the comparative study of a number of different samples. In my paper, often mentioned in the foregoing pages, I give the data for such a comparative study. Referring the reader to these facts, which since the paper was published, have been very much extended, I will here confine myself to one example, the result of the analyses of the samples of spring herring from the year 1914, as far as the 1904 year-class is concerned. In 1914 seven samples of spring herring were collected containing in all 1,933 herrings. The samples were collected from places along the west Norwegian coast, some places several hundred miles apart. Along all this distance the spring herring were spawning. The analysis gave the following result, as far as the 1904 year-class is concerned.

Number of individuals in the samples.	Percentage of year-class 1904.
175	52·6
305	58·4
44	59·1
565	62.3
354	60.7
289	50·2
201	61·2
Average.... 276	Average....57·8

In these seven samples the percentage of deviation from the average of 57·8 were as follows: 5·8, 0·6, 1·3, 4.5, 2·9, 7·6, 3·4. Similar results have also been obtained from other sources, (also from this year).[1]

It is difficult to explain this close correspondence in any other way than this: that the different year-classes of the spawning herring must be so evenly mixed that samples containing a few hundred (even forty-four) individuals will suffice in many cases to give approximate information of the percentage of each year-class represented in the stock. The data illustrated by fig. 14 will also give a convincing impression

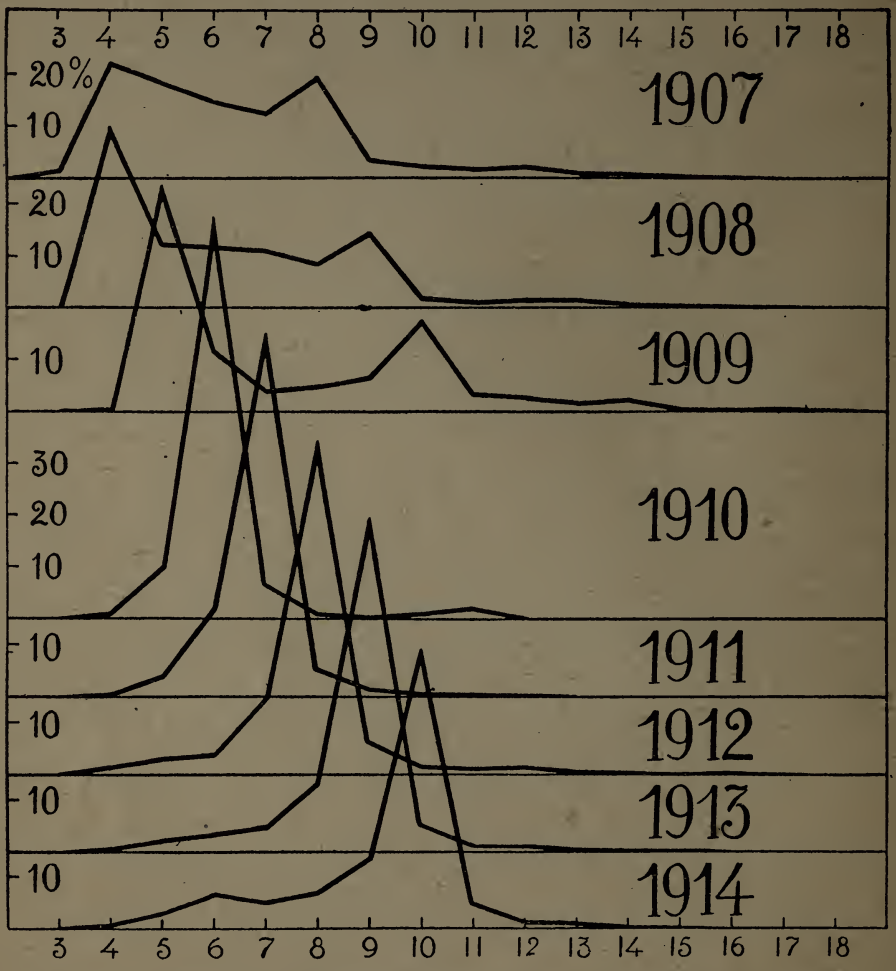


Fig. 14. Composition in point of age of Norwegian spring herring for the years 1907-1914; average of all samples examined in each year. For 1914 only samples from February included.

of the validity of the method. It seems impossible to explain the fact that the investigations through nine consecutive years have given the preponderance of one and the same year-class, if the method of investigation were unable to yield a representative picture of the composition of the stock.

The discussion of these results has been necessary for the following review of the preliminary investigation, which circumstances have allowed me to make regarding

[1] According to information sent me from Mr. Einar Lea.

the material collected from the Canadian waters. The material is naturally not so extensive as the material from Northern Europe, where investigations have been carried out for a series of years. The Canadian material is also, for other reasons, less reliable than the Norwegian material. For example, while most of the Norwegian material has been collected from catches made by seines (shore-seines and purse-seines), all sizes of herring present in the shoal being captured, the Canadian material is collected from catches made by gill-nets of large meshes (1½ to 1¾-inch meshes), which may let through a great many of the smaller individuals. It will therefore be necessary for the planned expedition both to collect more extensive material and to have collections made by means of specially arranged fishing experiments.

As an orientation of the problems before us it might, however, be advisable, with all possible reservation, to consider the data which have been obtained by the analysis of the material already before us.

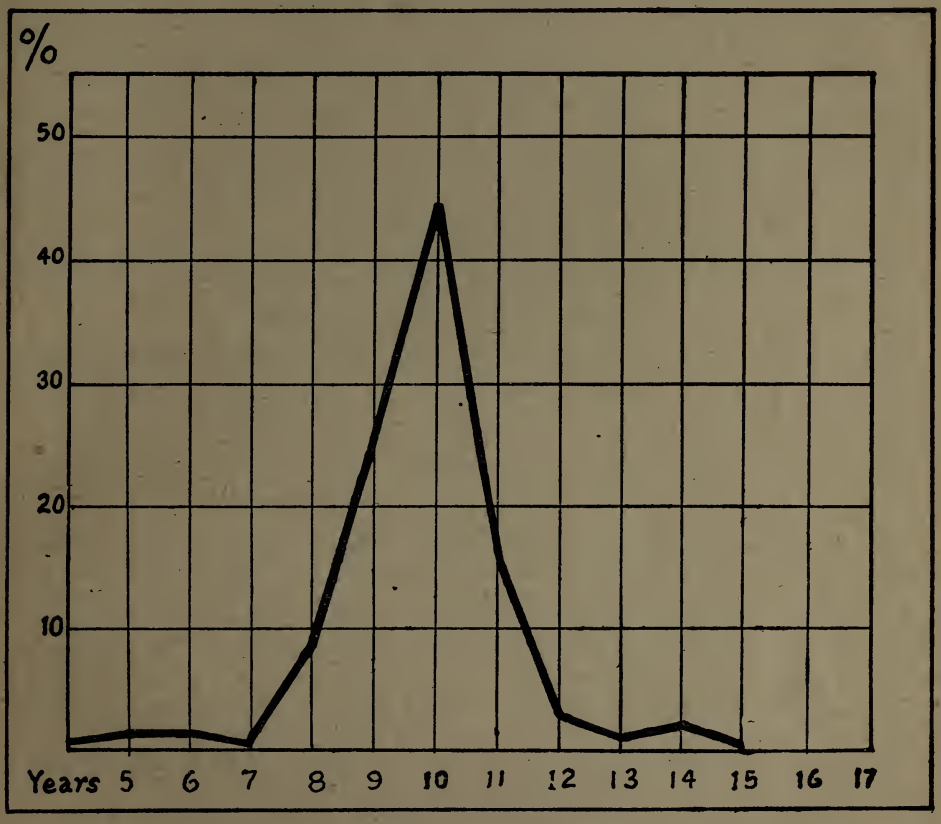


Fig. 15. Composition in point of age of spring herring from West Coast of Newfoundland (May, 1914.)

We will then, first of all, direct attention to the analysis of some samples from the west coast of Newfoundland. These herrings were, it will be remembered, in several respects, in the characteristics of their growth, very much like the Norwegian herrings. We should therefore also expect a similar composition with regard to age.

On the west coast of Newfoundland, herrings are caught in the spring, in the summer, and in the fall. The spring herrings are large, with mature roe and milt, and they are the spawning shoals and correspond to the Norwegian spring herring. The

herring spawning season seems everywhere in the gulf of St. Lawrence to be in May, that is about two months later in the year than on the Norwegian west coast. In the summer some fishing is going on in the bays. The catch consists, according to information obtained through conversation with fishermen, of smaller herring, which are used as bait only. The fall fishing is a very important one, large herring schools approaching the coast and entering the bays. This herring is large, with the sexual organs developing. They correspond thus entirely to the "large" herring, which are caught in Norway late in the fall.

TABLE No. 8.—Sample of Herring from Newfoundland (West Coast) about beginning of November, 1914.

Percentage of Different Ages in the Sample.

5	6	7	8	9	10	11	12	13	14
0·9	0·9	.....	8·0	24·8	44·2	15·8	2·7	0·9	1·8

TABLE No. 9.—Sample of Herring from Newfoundland (West Coast) about beginning of November, 1914.

Percentage of Different Ages in the Samples.

5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
3·1	2·1	8·3	2·1	3·1	18·8	43·8	5·2	2·1	1·0	2·1	5·2	1·0	1·0	..	1·0

The two tables 8 and 9 give the results of the analysis of two samples of herring from the westcoast of Newfoundland, one sample (table 8) was taken in the spring, another (table 9) in the fall of the year 1914; in all, the ages of several hundred herrings have been determined from this part of the gulf. A comparison of samples will first of all reveal the important fact that very few of the younger year-classes have been caught. This is especially the case in the samples taken in the spring (table 8), where practically no herring under 8 years are found. In the fall a little admixture of 5, 6 and 7-year old fish was found in two of the three samples (table 9).

This fact may be explained in one of two ways: either the spawning shoals of the west coast of Newfoundland, in the year 1914, consisted only of the older year-classes represented in the samples, or the younger year-classes were present but not caught by the large meshes of the fishermen's gill-nets. Which of these two explanations may be the right one cannot be decided with any definite certainty. For my own part, I am mostly inclined to the belief that the younger year-classes in the year 1914 were not very plentiful. I base this belief, which I do not wish to be regarded as anything more than a suggestion, on the fact that some of the samples contain individuals of the younger year-classes, but in small numbers; further, on my inspection of the fishermen's nets, which varied very much with regard to size of the meshes; and, in addition, the fishermen's statement, that there were but few herrings of smaller size this year, 1914. In the discussion of this question, a great need is felt of investigations as to the age when the Newfoundland herring first

reach maturity. No definite information could be obtained as to this, and it must therefore be left to future investigations, when the necessary facts in this respect can be collected. From the experience obtained through the European investigations it must be assumed that the two types of herrings, which have so much resemblance as to their rate of growth, may also reach their maturity at about the same age. If this is so, it must further be supposed that the spawning schools off the Newfoundland coasts in some years, in any case, must consist of large numbers of smaller and younger (4-, 5-, and 6-year-old fish), which to a great extent must go through the fishermen's nets and thus escape from being caught. . This point, which obviously has great theoretical and practical importance, should be kept in view in any further scientific researches, as well as in practical fishing experiments, such as will undoubtedly have to be made in future. It would be of great interest if such experiments could be made, during the coming spring.

We will now, with all the precaution and reservation immediately arising from the considerations just urged, again regard the two tables (8 and 9) and especially draw attention to the comparison of the figures of the percentage for the older year-classes, which are represented in the samples in great numbers.

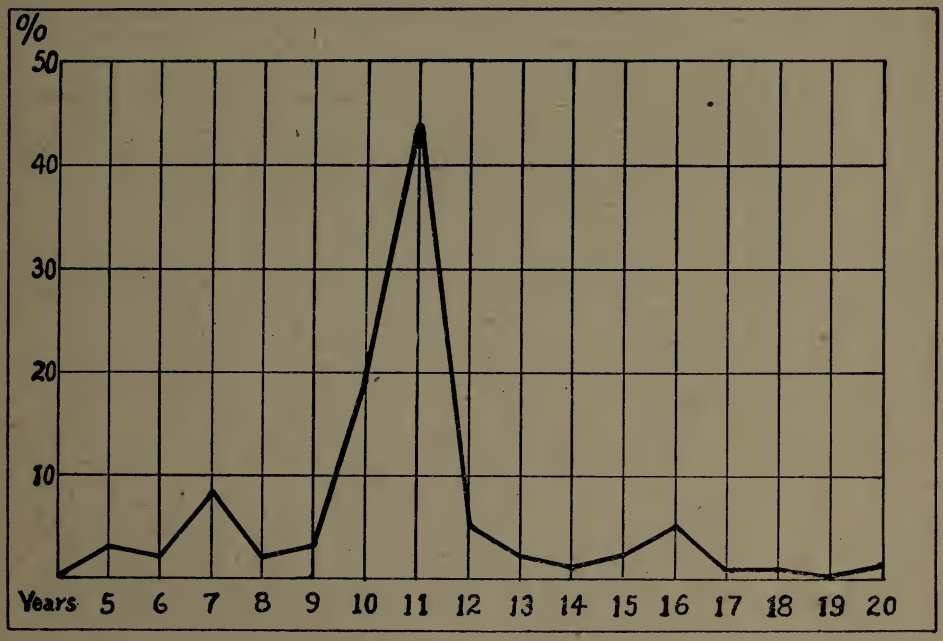


Fig. 16. Composition in point of age of fall herring from West Coast of Newfoundland (about beginning of November, 1914).

It may also be of interest to compare the two figures. 15 and 16, which are drawn on the basis of the figures contained in table 8 and 9. It will then be seen that the spring herring (table 9) for the greatest part consisted of three year-classes, the 9-, 10-, and 11-year old herring, amongst which the 10-year-old, born in the year 1904, predominated to such an extent that about half (44 per cent) of the total number of the individuals in the samples belonged to this single year-class. We have thus here again established the fact that great fluctuations occur in the number of the different year classes. Spawning schools of the Newfoundland herring resemble also in this respect the spawning schools of the Norwegian spring herring.

Still greater interest will be attached to this fact if we now compare the two tables 8 and 9. While in the table 8 the 9-, 10-, and 11-, and especially the 10-year-old hering were the dominant, we find in the samples of table 9 a preponderance of the 10-, and 11-year-old herrings, with a marked predominance amongst these year-classes of the 11-year-old herrings. The samples of the table 9 were collected in the fall (about beginning of November, 1914). The two series of herrings, that of table 8 and that of table 9 were both, it is true, caught in the same calendar year, 1914, but the series, nevertheless, belonged to two different periods of growth, to two different winter seasons. From the explanation of the methods of investigation here employed (see above, especially fig. 1), it will be remembered that the growth of the herrings exclusively takes place during summer, from April to September (inclusive). This holds good for the west coast of Norway, under the hydrographic conditions there prevalent. In the gulf of St. Lawrence the winter conditions last till late in May (a factor being the melting of the ice in the gulf), the spawning season of the fish is therefore some months later there than in the Norwegian waters, and the growth of the fish is limited to a somewhat different part of the year. In May the winter ring is still at the margin of the herring scales, and in November a new winter ring has been formed outside of the winter ring of the month of May. The individuals which in May had ten winter rings on their scales would therefore in the period from November, 1914, to May. 1915, have eleven rings marked on the scales. The two tables, 8 and 9, therefore reveal an instance of the same facts which were demonstrated for the Norwegian spring herrings (see fig. 14) that the predominance of the same year-class can be followed from one season to the other, as the same individuals again return to their own spawning areas. It is most striking that the richest year-class was that of 1904, the same year which produced such a rich stock of herrings in Norwegian waters. The far-reaching importance of this correspondence between the two stocks of herring on both sides of the Atlantic makes it still more necessary not to draw any definite conclusions from the comparatively small material which hitherto has been investigated. The reading of the Newfoundland scales is not easy. I have, therefore, felt the desire to compare my readings with those of Mr. Paul Bjerkan, and although we agree in our investigations of the samples mentioned here, I think it right to reserve any further discussion of the interesting problems which immediately arise from this study, till the whole material has been worked out. So much may in any case be said, that the samples have shown, that great fluctuations take place, and that future investigations must be carried on, if the understanding of the important biological and practical conditions of the herring fisheries of the American waters is ever to be obtained. The expedition of the coming season will, of course, have chiefly in view the continued observations upon these conditions. The Newfoundland herring forming my material are entirely confined to samples from the spring and fall schools, all of which are large mature fish. As far as I have been able to ascertain, no fishing takes place with the object in view of catching the younger, the "fat" herring. Only some few barrels of younger herring are caught in the bays for use as bait. Where then are the sizes of herrings which correspond to the Norwegian small and fat herring? Are they, as is the case along the Norwegian coast, mainly confined to some special areas of the coast or of the open waters in or outside the gulf? Do they anywhere occur in such quantities and under such circumstances that a new fishery could be developed? That the younger stages of herrings in any case must occur in larger quantities than the larger and older ones is quite clear. It may be that the younger year-classes are less numerous in a special year or shorter series of years (fig. 14), but during a longer period of years it is evident that older herring must be so much reduced in number, in comparison with the younger individuals, that the death-rate of the species will diminish their number. From our study of the growth of the Newfoundland herring it is evident that the 3, 4, 5 and 6-year-old herring, which to a larger or smaller degree may belong to the immature "fat" shoals, must possess the principal qualities of the Nor-

wegian fat herring which in Norway are caught in hundreds of thousands of barrels (cf. the table page 28). There seems to be a vast field for the most interesting scientific and practical investigations in the solution of these questions.

TABLE No. 10.—Samples of Herring from Gulf of St. Lawrence, May, 1914.

Sample.	Number of Individuals in Sample.	Percentage of Different Ages in the Samples.													
		4	5	6	7	8	9	10	11	12	13	14	15	16	17
Q_1.	43	9·3	16·3	4·7	30·2	2·3	7·0	7·0	23·3	.....	.....	.....	.....	.....	.....
M.	151	7·3	1·3	6·0	10·6	15·2	11·3	13·3	27·2	4·6	0·7	1·3	0·7	.....	0·7

Q^1—Northumberland Strait.
M—Magdalen Islands.

Table 10 gives a summary of the percentage of the different ages in two samples from the southern part of the gulf of St. Lawrence, of which the one sample has already been treated in table 5. We find in this table many more year-classes represented than amongst the samples from Newfoundland, the younger, 4 and 5-year-old fish being more represented. There is, further, not such a strongly marked difference to be observed between the year classes. No single year-class has so much as half of the individuals of the whole sample. (See table 10.)

The 10-year-old herrings, which played such a great role in the Newfoundland material, are only very few amongst these herring from the southern part of the gulf. We find, on the other hand, a marked preponderance of the 11-year-old herrings amongst these gulf herring. There is then no correspondence with regard to the predominance of certain year-classes between the Newfoundland and the Magdalen Island herrings, just as there is no correspondence, in this respect, between the herrings of the Norwegian coast and the shoals around the British Islands. These different types live, each of them, under special conditions, not only as regards their growth but also as regards the renewal of their stock. The Magdalen Island herring have also this in common with the North Sea herring, that the fluctuations in the year-classes are smaller than in the Norwegian and the Newfoundland herring.

Between the two samples (table 10) there is an interesting difference. The Magdalen Island sample consists of older individuals than the sample from the inshore Northumberland strait. It will be necessary to investigate this more closely and to ascertain if this difference is due to the method of fishing or to some peculiarity in the life-history of these herring.

My material contains no sample of younger, immature herring, from the southern area of the gulf. It is, in this connection, of interest to note that Mr. J. J. Cowie, from the experience of his fishing experiments, has drawn attention to the occurrence of schools of younger herring in the gulf, which he compares with the Scotch "Matjes." From the investigations of the growth of these herring of the gulf it should be anticipated that the smaller and younger herring of this type must be very similar to the young North Sea herring, and the indications given by Mr. Cowie will be of the greatest interest for further investigations.

TABLE No. 11.—Samples of Herrings from Atlantic Coast of Nova Scotia, Fall, 1914.

Sample.	Number of Individuals in Sample.	Percentage of Different Ages in Sample.										
		3	4	5	6	7	8	9	10	11	12	13
A.....	60	5	90	5	. ..	.....	.....	.....	. ...	.....	.....	.....
E....	135	....	.....	3	5·9	16·3	11·1	31· 1	17·9	11·9	1·5	1·5

A. Young immature herrings from Halifax harbour.
E. Spawning Lockeport.

In table II, I give the result of two samples (already treated in tables 2 and 3). Sample "A" from Halifax harbour contained only young, immature herring; sample "E" mature herring from the Atlantic coast of Nova Scotia. I will here confine myself to simply setting forth figures of the table which have their chief interest through comparison that will be afforded by similar material to be collected during future investigations.